

SECTION 01 74 19 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for the following:
 - 1. Salvaging nonhazardous demolition and construction waste.
 - 2. Recycling nonhazardous demolition and construction waste.
 - 3. Disposing of nonhazardous demolition and construction waste.

1.3 DEFINITIONS

- A. Construction Waste: Building, structure, and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.
- B. Demolition Waste: Building, structure, and site improvement materials resulting from demolition operations.
- C. Disposal: Removal of demolition or construction waste and subsequent salvage, sale, recycling, or deposit in landfill, incinerator acceptable to authorities having jurisdiction, or designated spoil areas on Owner's property.
- D. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.
- E. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.
- F. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.

1.4 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition and construction waste becomes property of Contractor.

1.5 ACTION SUBMITTALS

- A. Waste Management Plan: Submit plan within 7 days of date established for the Notice to Proceed.

1.6 INFORMATIONAL SUBMITTALS

- A. Waste Reduction Progress Reports: Concurrent with each Application for Payment, submit report. Use Form CWM-7 for construction waste and Form CWM-8 for demolition waste. Include the following information:
 - 1. Material category.
 - 2. Generation point of waste.
 - 3. Total quantity of waste in tons.
 - 4. Quantity of waste salvaged, both estimated and actual in tons.
 - 5. Quantity of waste recycled, both estimated and actual in tons.
 - 6. Total quantity of waste recovered (salvaged plus recycled) in tons.
 - 7. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.
- B. Waste Reduction Calculations: Before request for Substantial Completion, submit calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.
- C. Records of Donations: Indicate receipt and acceptance of salvageable waste donated to individuals and organizations. Indicate whether organization is tax exempt.
- D. Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals and organizations. Indicate whether organization is tax exempt.
- E. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
- F. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
- G. **LEED Submittal**: Submit documentation to USGBC, signed by Contractor, tabulating total waste material, quantities diverted and means by which it is diverted, and statement that requirements for the credit have been met. Respond to questions and requests from USGBC regarding construction waste management and disposal until the USGBC has made its determination on the Project's LEED certification application. Document correspondence with USGBC as informational submittals.
- H. Qualification Data: For waste management coordinator and refrigerant recovery technician.
- I. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

- J. Refrigerant Recovery: Comply with requirements in Section 024119 "Selective Demolition" for refrigerant recovery submittals.

1.7 QUALITY ASSURANCE

- A. Waste Management Coordinator Qualifications: Experienced firm, or individual employed and assigned by General Contractor, with a record of successful waste management coordination of projects with similar requirements. Superintendent may serve as Waste Management Coordinator.
 - 1. Firm employs a LEED-Accredited Professional, certified by the USGBC, as waste management coordinator.
 - 2. Waste management coordinator may also serve as LEED coordinator.
- B. Refrigerant Recovery Technician Qualifications: Universal certified by EPA-approved certification program.
- C. Regulatory Requirements: Comply with transportation and disposal regulations of authorities having jurisdiction.
- D. Waste Management Conference(s): Conduct conference(s) at Project site to comply with requirements in Section 013100 "Project Management and Coordination." Review methods and procedures related to waste management including, but not limited to, the following:
 - 1. Review and discuss waste management plan including responsibilities of each contractor and waste management coordinator.
 - 2. Review requirements for documenting quantities of each type of waste and its disposition.
 - 3. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
 - 4. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
 - 5. Review waste management requirements for each trade.

1.8 WASTE MANAGEMENT PLAN

- A. General: Develop a waste management plan according to requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. Distinguish between demolition and construction waste. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.
- B. Waste Identification: Indicate anticipated types and quantities of demolition and construction waste generated by the Work. Use Form CWM-1 for construction waste and Form CWM-2 for demolition waste. Include estimated quantities and assumptions for estimates.
- C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Use Form CWM-3 for construction waste and Form CWM-4 for demolition waste. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.

1. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work in compliance with Section 024119 "Selective Demolition."
 2. Salvaged Materials for Sale: For materials that will be sold to individuals and organizations, include list of their names, addresses, and telephone numbers.
 3. Salvaged Materials for Donation: For materials that will be donated to individuals and organizations, include list of their names, addresses, and telephone numbers.
 4. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
 5. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
 6. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location where materials separation will be performed.
- D. Cost/Revenue Analysis: Indicate total cost of waste disposal as if there were no waste management plan and net additional cost or net savings resulting from implementing waste management plan. Use Form CWM-5 for construction waste and Form CWM-6 for demolition waste. Include the following:
1. Total quantity of waste.
 2. Estimated cost of disposal (cost per unit). Include transportation and tipping fees and cost of collection containers and handling for each type of waste.
 3. Total cost of disposal (with no waste management).
 4. Revenue from salvaged materials.
 5. Revenue from recycled materials.
 6. Savings in transportation and tipping fees by donating materials.
 7. Savings in transportation and tipping fees that are avoided.
 8. Handling and transportation costs. Include cost of collection containers for each type of waste.
 9. Net additional cost or net savings from waste management plan.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General: Achieve end-of-Project rates for salvage/recycling of 75 percent by weight of total nonhazardous solid waste generated by the Work. Practice efficient waste management in the use of materials in the course of the Work. Use all reasonable means to divert construction and demolition waste from landfills and incinerators. Facilitate recycling and salvage of materials, including demolition waste, construction waste and construction office waste.

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

- A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.
 - 1. Comply with operation, termination, and removal requirements in Section 015000 "Temporary Facilities and Controls."
- B. Waste Management Coordinator: Engage a waste management coordinator to be responsible for implementing, monitoring, and reporting status of waste management work plan.
- C. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work.
 - 1. Distribute waste management plan to everyone concerned within three days of submittal return.
 - 2. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.
- D. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 - 1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged and recycled.
 - 2. Comply with Section 015000 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

3.2 SALVAGING DEMOLITION WASTE

- A. Comply with requirements in Section 024119 "Selective Demolition" for salvaging demolition waste.
- B. Salvaged Items for Reuse in the Work: Salvage items for reuse and handle as follows:
 - 1. Clean salvaged items.
 - 2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
 - 3. Store items in a secure area until installation.
 - 4. Protect items from damage during transport and storage.
 - 5. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.
- C. Salvaged Items for Sale and Donation: Not permitted on Project site.

- D. Salvaged Items for Owner's Use: Salvage items for Owner's use and handle as follows:
 - 1. Clean salvaged items.
 - 2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
 - 3. Store items in a secure area until delivery to Owner.
 - 4. Transport items to Owner's storage area on-site.
 - 5. Protect items from damage during transport and storage.
- E. Doors and Hardware: Brace open end of door frames. Except for removing door closers, leave door hardware attached to doors.
- F. Equipment: Drain tanks, piping, and fixtures. Seal openings with caps or plugs. Protect equipment from exposure to weather.
- G. Plumbing Fixtures: Separate by type and size.
- H. Lighting Fixtures: Separate lamps by type and protect from breakage.
- I. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.

3.3 RECYCLING DEMOLITION AND CONSTRUCTION WASTE, GENERAL

- A. General: Recycle paper and beverage containers used by on-site workers.
- B. Recycling Incentives: Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall be shared equally by Owner and Contractor.
- C. Preparation of Waste: Prepare and maintain recyclable waste materials according to recycling or reuse facility requirements. Maintain materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.
- D. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical according to approved construction waste management plan.
 - 1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.
 - a. Inspect containers and bins for contamination and remove contaminated materials if found.
 - 2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
 - 4. Store components off the ground and protect from the weather.

5. Remove recyclable waste from Owner's property and transport to recycling receiver or processor as often as required to prevent overfilling bins.

3.4 RECYCLING DEMOLITION WASTE

- A. Asphalt Paving: Break up and transport paving to asphalt-recycling facility.
- B. Concrete: Remove reinforcement and other metals from concrete and sort with other metals.
- C. Masonry: Remove metal reinforcement, anchors, and ties from masonry and sort with other metals.
 1. Clean and stack undamaged, whole masonry units on wood pallets.
- D. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.
- E. Metals: Separate metals by type.
 1. Structural Steel: Stack members according to size, type of member, and length.
 2. Remove and dispose of bolts, nuts, washers, and other rough hardware.
- F. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.
- G. Acoustical Ceiling Panels and Tile: Stack large clean pieces on wood pallets and store in a dry location.
- H. Metal Suspension System: Separate metal members, including trim and other metals from acoustical panels and tile, and sort with other metals.
- I. Carpet and Pad: Roll large pieces tightly after removing debris, trash, adhesive, and tack strips.
 1. Store clean, dry carpet and pad in a closed container or trailer provided by carpet reclamation agency or carpet recycler.
- J. Carpet Tile: Remove debris, trash, and adhesive.
 1. Stack tile on pallet and store clean, dry carpet in a closed container or trailer provided by carpet reclamation agency or carpet recycler.
- K. Piping: Reduce piping to straight lengths and store by material and size. Separate supports, hangers, valves, sprinklers, and other components by material and size.
- L. Conduit: Reduce conduit to straight lengths and store by material and size.
- M. Lamps: Separate lamps by type and store according to requirements in 40 CFR 273.

3.5 RECYCLING CONSTRUCTION WASTE

A. Packaging:

1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
2. Polystyrene Packaging: Separate and bag materials.
3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.

B. Wood Materials:

1. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
2. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.

C. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location.

1. Clean Gypsum Board: Grind scraps of clean gypsum board using small mobile chipper or hammer mill. Screen out paper after grinding.

D. Paint: Seal containers and store by type.

3.6 DISPOSAL OF WASTE

A. General: Except for items or materials to be salvaged or recycled, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.

1. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

B. General: Except for items or materials to be salvaged or recycled, remove waste materials and legally dispose of at designated spoil areas on Owner's property.

C. Burning: Do not burn waste materials.

3.7 ATTACHMENTS

A. The following forms will be provided to the contractor subsequent to the issuance of a Notice To Proceed:

1. Form CWM-1 for construction waste identification.
2. Form CWM-2 for demolition waste identification.

Addendum No. 1

THE CITY OF PHILADELPHIA
Office of Emergency Management

3. Form CWM-3 for construction waste reduction work plan.
4. Form CWM-4 for demolition waste reduction work plan.
5. Form CWM-5 for cost/revenue analysis of construction waste reduction work plan.
6. Form CWM-6 for cost/revenue analysis of demolition waste reduction work plan.
7. Form CWM-7 for construction waste reduction progress report.
8. Form CWM-8 for demolition waste reduction progress report.

END OF SECTION 01 74 19

SECTION 01 91 13 – GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 Concord engineering has been selected as the commissioning authority to provide commissioning services for this project. The intent of these commissioning specifications is to:

- A. Familiarize the Contractors with the commissioning process and emphasize the differences between a commissioned and a non commissioned project.
- B. Specify the labor, and tasks which are required by the contractors to support and comply with the commissioning requirements of this project; thus allowing the contractors to properly estimate the cost of the commissioning work with in their scope.

1.2 RELATED /DIVISIONS AND SECTIONS

- A. Drawings and general provisions of the Contract, including General and Supplemental Conditions and other Division 1 Specification Sections, apply to this Section. Specific Commissioning (Cx) requirements are given in the following sections of these specifications. All of the following sections apply to the Work of this section:
 - 1. 230910 HVAC Cx - Describes the Cx responsibilities of the Mechanical, Controls and TAB Contractors and the pre-functional and functional testing responsibilities of each.

1.3 RELATED DOCUMENTS

- A. AHRAE Guideline 0-2005 “The Commissioning Process”

1.4 DEFINITIONS

- A. **A/E:** Architect & Engineer
- B. **Building Systems Commissioning:** Commissioning is the process that ensures building systems are designed, installed, functionally tested, and capable of being operated and maintained in conformance with the design intent (owner’s requirements). Commissioning for this project follows requirements outlined in ASHRAE Guideline 1-1996 “The HVAC Commissioning Process”. This standard approach will be applied to all commissioned systems.
- C. **Pre Functional check:** A checking process requiring the GC/Sub’s completion of comprehensive Installation Check Sheets to verify that the equipment has been correctly installed as per the contract documents.

- D. **Functional check:** Individual component and comprehensive system checks. These checks verify that components operate correctly in a standalone type situation and that components work correctly together as an overall system. Functional checks are concerned with correct sequences of operation and primary safety and efficiency concerns such as temperature and equipment interlocks. Functional checks are first applied to local components and controls (such as a motor, starter and disconnect) and are then applied to complete systems (such as a pump and pressure sensor and the central workstation command center). The end goal is that all associated equipment and components are verified simultaneously to ensure that all elements operate as per the contract documents.
- E. **Commissioning Plan:** A document defining the Cx process, scope, team and milestones/goals throughout the entire project from the inception of commissioning through training and turnover to the customer.
- F. **Issue:** Any defects, problems, and deficiencies that do not meet contract requirements or the intent of the project design. All Issues are entered into a database by the Commissioning Authority to enable tracking and closeout.
- G. **Abbreviation:** The following are common abbreviations used in this section:

AHU	Air Handling Unit	O&M	Operation and Maintenance
CxA	Commissioning Authority	PT	Performance Test
Cx	Commissioning	SOP	Sequence of Operation
FC	Functional Check	Subs	Sub-Contractors
GC	General Contractor	TAB	Test, Adjust, Balance
HVAC	Heating, Ventilation, Air-Conditioning	VAV	Variable Air Volume Unit

1.5 DESCRIPTION

A. Summary

1. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. The commissioning process does not take away from, or reduce the responsibility of, the General Contractor and installing subcontractors to provide a finished and fully-functioning product.

B. Purpose.

1. Commissioning during the construction phase is intended to achieve the following specific objective according to the Contract Documents:
 - a. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.

- b. Verify and document proper performance of equipment and systems.
- c. Verify that O&M documentation left on site is complete.
- d. Verify that the Owner's operating personnel are adequately trained.

1.6 COORDINATION

- A. Commissioning Team. The members of the commissioning team consist of the designated representative of the Owner, Commissioning Authority (CA), the Architect and Design Engineers (particularly the mechanical engineer) (A/E), General Contractor (GC), the Mechanical Contractor (MC), the Testing Adjusting and Balancing (TAB) representative, the Electrical Contractor (EC), the Controls Contractor (CC), the Plumbing Contractor (PC) and the Fire Protection Contractor (FPC). If known, the Owner's building operator/engineer is also a member of the commissioning team.
- B. Management. The CA has been hired by the Owner. The CA directs and coordinates the commissioning activities and is part of the design team. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
- C. Scheduling. The CA will work with the Cx team according to established protocols to schedule the commissioning activities. The CA will provide sufficient notice to the Cx team for scheduling commissioning activities. The CM will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

1.7 COMMISSIONING PROCESS

- A. The following narrative provides a brief overview of the typical commissioning tasks during Construction and the general order in which they occur.
 - 1. Commissioning during construction begins with a scoping meeting conducted by the CA where the commissioning process is reviewed with the commissioning team members.
 - 2. Additional meetings will be required throughout construction, scheduled by the CA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
 - 3. Equipment documentation is submitted to the CA during normal submittals, including detailed start-up procedures.
 - 4. The CA works with the GC and the Subcontractors/equipment suppliers in developing startup plans and startup documentation formats.
 - 5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with pre-functional checklists being completed before functional testing.
 - 6. The Subs, under their own direction, execute and document the pre-functional checklists and perform startup and initial checkout. The CA documents that the checklists and startup were completed according to the approved plans. This will include the CA witnessing start-up of selected equipment.

7. The CA develops specific equipment and system functional performance test procedures. The Subcontractors review the procedures.
8. The procedures are executed by the Subcontractors, under the direction of, and documented by the CA.
9. Items of non-compliance in material, installation or setup are corrected at the Subcontractors' expense and the system retested.
10. The CA reviews the O&M documentation for completeness.
11. Commissioning is completed before Substantial Completion.
12. The CA reviews, pre-approves and witnesses the training provided by the Subcontractors and verifies that it was completed.
13. Deferred testing is conducted, as specified or required.

1.8 RELATED WORK

- A. Specific Commissioning (Cx) requirements are listed in the sections listed above in RELATED /DIVISIONS AND SECTIONS of these specifications. All of these sections apply to the Work of this section:

1.9 RESPONSIBILITIES

- A. The responsibilities of various parties in the commissioning process are provided in this section. It is noted that the services for the Architect, MEP Designers/Engineers, and Commissioning Authority are not provided for in this contract. That is, the Contractor is not responsible for providing their services. Their responsibilities are listed here to clarify the commissioning process.

- B. All Parties

1. Follow the Commissioning (Cx) Plan.
2. Attend commissioning scoping meeting and additional Cx meetings, as necessary.

- C. Mechanical, Electrical and Plumbing Designers/Engineers

(Design, Construction and Acceptance Phase)

1. Perform normal submittal review, construction observation, as-built drawing preparation, etc., as contracted. One site observation should be completed just prior to system startup.
2. Provide any design narrative and sequences documentation requested by the CA. The designers shall assist (along with the contractors) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
3. Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.
4. Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

5. Edit and update one-line diagrams developed as part of the design narrative documentation and those provided by the vendor as shop drawings for the various Mechanical, Electrical, and Plumbing systems.

D. Commissioning Authority (CA)

The CA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CA may assist with problem-solving non-conformance or deficiencies, but ultimately that responsibility resides with the A/E. The primary role of the CA is to develop and coordinate the execution of a testing plan, observe and document performance. The Contractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems.

Design, Construction and Acceptance Phase

1. Coordinate the commissioning work and, with the A/E, ensure that commissioning activities are being scheduled into the master schedule.
2. Plan and conduct a commissioning scoping meeting, start-up and deficiency meetings as required.
3. Request and review additional information required to perform commissioning tasks, including O&M materials, control sequences, contractor start-up and checkout procedures.
4. Before startup, gather and review the current control sequences and interlocks and write detailed testing procedures.
5. Review and approve normal Contractor submittals applicable to systems being commissioned for compliance with commissioning needs.
6. Write and distribute pre-functional tests and checklists.
7. Perform site visits, as necessary, to observe component and system installations. Attends selected planning and job-site meetings to obtain information on construction progress.
8. Witness all or part of the HVAC/Plumbing piping test and flushing procedure, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify the A/E of any deficiencies in results or procedures.
9. Approve pre-functional tests and checklist completion by reviewing pre-functional checklist reports and by selected site observation and spot-checking.
10. Approve systems startup by reviewing start-up reports and by selected site observation.
11. Review TAB execution plan.
12. Analyze any functional performance trend logs and monitoring data to verify performance.
13. Compile and maintain a commissioning record and building systems book(s).
14. Review and approve the preparation of the O&M manuals.
15. Provide a final commissioning report.

E. Architect/Engineering Firm

Design, Construction and Acceptance Phase

1. Facilitate the coordination of the commissioning work by the CA, and, with the CA, ensure that commissioning activities are being scheduled into the master schedule.
2. Review and approve the final Construction Commissioning Plan.
3. Attend a commissioning scoping meeting and other commissioning team meetings as needed.
4. When necessary, observe and witness pre-functional checklists, startup and functional testing of selected equipment
5. Review commissioning progress and deficiency reports.

F. Equipment Suppliers

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
2. Assist in equipment testing per agreements with Subcontractors.
3. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor. Through the contractors they supply products to, analyze specified products and verify that the designer has specified the newest most updated equipment reasonable for this project's scope.
4. Provide information requested by CA regarding equipment sequence of operation and testing procedures.
5. Review test procedures for equipment installed by authorized factory representatives.

G. Controls & TAB Contractors

1. Controls & TAB Contractors will be responsible to carry out the commissioning requirements specified in Section 230910.

1.10 SYSTEMS TO BE COMMISSIONED

- A. This project will require integrated total building commissioning to include all of the following systems:

Plumbing Systems
Heating, Ventilation and Air Conditioning Systems
Building Automation Systems
Electrical Systems

PART 2 - PRODUCTS – (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 REPORTING

- A. The CA will provide regular field reports to the Owner as construction and commissioning progresses.
- B. The CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos and progress reports.
- C. A final summary report by the CA will be provided to the Owner. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report. Pre-functional checklists, functional tests and monitoring reports will not be part of the final report, but will be stored in the Commissioning Record in the O&M manuals.

3.2 Start-up, Pre-functional Checklists And Initial Checkout

- A. The following procedures apply to all equipment to be commissioned, according to Section 1.9, "SYSTEMS TO BE COMMISSIONED"
 - 1. Pre-functional checklist.
 - 2. Start-up: The start-up plan shall consist of:
 - a. The CA's pre-functional checklist.
 - b. The manufacturer's standard start-up procedure
 - c. The manufacturer's standard field checkout sheets.
- B. Execution of Pre-functional Checklists and Startup.
 - 1. The CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units. In no case will the number of units witnessed be less than 25% of the total number of identical or very similar units.
 - 2. For lower-level components of equipment, (e.g., unit heaters, sensors, controllers), the CA shall observe a sampling of the pre-functional and start-up procedures. The sampling procedures are identified in the commissioning plan.
 - 3. The Subs and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and pre-functional tests and checklists for 100% of all commissioned equipment.
- C. Deficiencies, Non-Conformance and Approval in Checklists and Startup.

1. The Subs shall clearly list any outstanding items of the initial start-up and pre-functional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CA within two days of test completion.
2. The CA reviews the report and submits either a non-compliance report or an approval form to the A/E. The CA shall work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CA recommends approval of the execution of the checklists and startup of each system.

3.3 FUNCTIONAL PERFORMANCE TESTING

- A. This sub-section applies to all commissioning functional testing for all divisions.
- B. The general list of equipment to be commissioned is found in Section 1.6 of this specification
- C. **Objectives and Scope.** The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required.
- D. **Development of Test Procedures.** Before test procedures are written, the CA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. The CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor responsible to execute a test shall provide assistance to the CA in developing the procedures review. Prior to execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection. The CA shall review owner-contracted, factory testing or required owner acceptance tests which the CA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.
- E. **Coordination and Scheduling.** The Subs shall provide sufficient notice to the CA regarding their completion schedule for the pre-functional checklists and startup of all equipment and systems. The CA will schedule functional tests through the A/E and affected Subs. The CA shall direct, witness and document the functional testing of selected equipment and systems. The Subs shall execute the tests.

- F. In general, functional testing is conducted after pre-functional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. **Documentation.** The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the CA for review and approval and to the Subs for review. Samples of typical Pre functional and Functional Check forms are included in this specification to illustrate the typical steps which the contractors will need to complete to demonstrate compliance.

- B. **Non-Conformance.**

1. The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the Owner. These results shall be presented in the Issues log. The issues log will be used throughout the job for documenting issues and their subsequent correction.
2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA.
3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the Owner.
4. The CA will await for the contractors to report, in writing, that deficiencies reported in the Issues log have been corrected. Once the CA receives notification that the deficiencies have been corrected the CA will back check the issue and verify that the issue has been corrected and will close out the issue.
5. If the results of the back check are that the issue still exist the item will remain open and the contractor will be notified of the deficiency.
6. The CA will perform some back checks as part of their contract. If repeated back checks are required, back charges to the responsible contractor may be incurred. The CA will keep a record of the time required to perform the additional back checks. The CM will verify the time required by signing the CAs field visit time sheet on the day (s) the additional back checks are performed.

- C. **Approval.** The CA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CA.

3.5 OPERATION AND MAINTENANCE MANUALS

A. Commissioning Record in O&M Manuals.

1. The CA is responsible to compile, organize and index the following commissioning data by equipment into labeled, indexed and tabbed, three-ring binders and deliver it to the Owner. Three copies of the manuals will be provided.
2. The information will also be provided in Digital format as well
3. Final Report Details. The final commissioning report shall include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the commissioning authority regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas: 1) Equipment meeting the equipment specifications, 2) Equipment installation, 3) Functional performance and efficiency, 4) Equipment documentation and design intent, and 5) Operator training. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented.

3.6 TRAINING OF OWNER PERSONNEL

- A. The GC shall be responsible for training coordination and scheduling, and ultimately for ensuring that training is completed.
- B. The CA shall be responsible for approving the content and adequacy and witnessing of the training of owner personnel for commissioned equipment.
- C. Each contractor responsible for training will provide a syllabus for the content of each class to the CA for approval two weeks prior to the training.

3.7 DEFERRED TESTING

- A. **Unforeseen Deferred Tests.** If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the Owner. These tests will be conducted in the same manner as the seasonal tests as soon as possible.
- B. **Seasonal Testing.** During the warranty period, seasonal testing shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.

3.8 SAMPLE TEST FORMS

Contractor Pre-Functional Commissioning Test Form

Provided by Concord Engineering

for

Facility: Sample Form

Air Handler: Sample Form

Pre-functional checklist items are to be completed as part of startup & initial checkout, preparatory to functional testing.

- This checklist does not take the place of the manufacturer’s recommended checkout and startup procedures or report.
- Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
- If this form is not used for documenting, one of similar rigor can be used as a replacement but must be approved by the CA and the Owner or their Representative.
- The General Contractor is responsible for all sections of the checklist and will be responsible to see that the appropriate checklist items by their subcontractors are completed and checked off. This is solely the responsibility of the General Contractor when they are functioning as a Single Prime. In the event the project is functioning with Multiple Primes all contractors are required to verify completion by signing and dating in the appropriate section.
- The pre-functional test form needs to be submitted to the CA for review prior to functional performance testing. The CA will not perform pre-functional review of the equipment until the completed pre-functional forms are provided by the GC or contractors.
- A/E = architect/engineer, All = all contractors, CA = commissioning agent, CC = controls contractor, EC = electrical contractor, GC = general contractor, MC = mechanical contractor, SC = sheet metal contractor, TAB = test, adjust and balance contractor.

Approvals: This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted below.

Responsible Contractor	Date	Owner’s Representative	Date
------------------------	------	------------------------	------

General Contractor shall provide check marks in appropriate locations on form. If an item does not apply the area shall be marked N/A. Problems, suggestions or recommendations shall be identified with a number and noted in the comment section at the end of the test form.

1. Requested documentation submitted

Equipment Tag →		Comments
Manufacturer's cut sheets		
Performance data (fan curves, coil data, etc.)		
Installation and startup manual and plan		
Sequences and control strategies		

- *Documentation complete as per contract documents.* **YES** **NO**

2. Model verification

Equipment Tag →	
Manufacturer	
Model No.	
Cooling Capacity	
Refrigerant Type	
Starter Model	
Voltage/Ph/A	

- *The equipment installed matches the specifications for given trade.* **YES** **NO**

3. Pre-Functional Checks

Item Checked	Y/N	Comment #
Equipment Tag →		
General Installation		
General appearance good, no apparent damage		
Proper vibration isolators installed and adjusted		
Factory Insulation not punctured, torn, etc.		

Addendum No. 1

Item Checked	Y/N	Comment #
Equipment Tag →		
Isolation valves and balancing valves installed		
Pipe fittings and accessories complete		
Pipes not supported on chiller		
VFD factory mounted with Circuit Breaker		
Two chiller lead/lag controls		

Item Checked	Y/N	Comment #
Equipment Tag →		
Test plugs installed near all control sensors and as per spec		
Flow switch installed as required?		
Flow meters installed?		
Proper refrigerant level?		
No refrigerant leakage?		
Proper oil types?		
Proper oil level?		
Purge unit installed, if specified?		
Piping type and flow direction labeled on piping?		
Equipment labels affixed?		
Oil heater installed properly?		
Size of over current heater in motor starter correct?		
Oil filter clean?		
Master control panel for sequence control of heat exchangers, pumps, chillers, tower fans, etc.?		
Electrical and Controls		
Power wiring installed properly?		
All electrical components grounded properly?		
Control wiring and control system hooked up?		
Sensors calibrated (see calibration section below)?		
Control system interlocks hooked up and functional?		
Fuses sizes correct as per mfg submittals?		
All control devices, pneumatic tubing and wiring complete?		
Safeties installed and safe operating ranges for this equipment provided to the commissioning agent?		
Chilled water piping and pumps pre-functional checklists completed?		

- *The checklist items of Part 4 are all successfully completed for given trade.* YES NO

Comments:

1. _____
2. _____
3. _____
4. _____
5. _____

Contractor Functional Commissioning Test Form

Provided by Concord Engineering

for

Facility: Sample Form

Air Handling Unit: Sample Form

Pre-functional checklist items are to be completed as part of startup & initial checkout, preparatory to functional testing.

- This checklist does not take the place of the manufacturer’s recommended checkout and startup procedures or report.
- Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
- If this form is not used for documenting, one of similar rigor can be used as a replacement but must be approved by the CA and the Owner or their Representative.
- The General Contractor is responsible for all sections of the checklist and will be responsible to see that the appropriate checklist items by their subcontractors are completed and checked off. This is solely the responsibility of the General Contractor when they are functioning as a Single Prime. In the event the project is functioning with Multiple Primes all contractors are required to verify completion by signing and dating in the appropriate section.
- The pre-functional test form needs to be submitted to the CA for review prior to functional performance testing. The CA will not perform pre-functional review of the equipment until the completed pre-functional forms are provided by the GC or contractors.
- A/E = architect/engineer, All = all contractors, CA = commissioning agent, CC = controls contractor, EC = electrical contractor, GC = general contractor, MC = mechanical contractor, SC = sheet metal contractor, TAB = test, adjust and balance contractor.

Approvals: This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted below.

Responsible Contractor	Date	Owner’s Representative	Date
------------------------	------	------------------------	------

General Contractor shall provide check marks in appropriate locations on form. If an item does not apply the area shall be marked N/A. Problems, suggestions or recommendations shall be identified with a number and noted in the comment section at the end of the test form.

1. Requested documentation submitted

Equipment Tag →		Comments
Training documentation		
Final TAB report		
Startup report		
O&M Manuals		

- *Documentation complete as per contract documents.* **YES** **NO**

2. Model verification

Equipment Tag →	
Manufacturer	
Model No.	
Cooling	
Capacity	
Heating	
Capacity	
S Fan	
Capacity/HP	
R/E Fan	
Capacity/HP	
VFD	

- *The equipment installed matches the specifications for given trade.* **YES** **NO**

3. Functional Checks

Item Checked	Y/N	Comment #
Equipment Tag →		
Supply fan rotation correct		
Return / exhaust fan rotation correct		
No unusual noise or vibration in supply and exhaust fans		
Condenser fan rotation correct (air cooled)		
Condenser fan acceptable noise and vibration (air cooled)		
Measure line to line voltage imbalance for 1/3 of the compressors: Compressor 1 Phase: (%Imbalance = 100 x (avg. - lowest) / avg.) Record in cell, all three phase voltages. Imbalance less than 2%?		
Compressor 2 Phase: (%Imbalance = 100 x (avg. - lowest) / avg.) Record in cell, all three phase voltages. Imbalance less than 2%?		
Record full load running amps for each compressor. _____rated FL amps x _____srvc factor = _____ (Max amps). Running less than max?		
Record full load running amps for each condenser fan. _____rated FL amps x _____srvc factor = _____ (Max amps). Running less than max?		
Fans > 5 hp Phase Checks: (% imbalance = 100 x (avg. - lowest) / avg.) List fan & record all 3 voltages in cell. Imbalance less than 2%?		
Record full load running amps for each fan. _____rated FL amps x _____srvc factor = _____ (Max amps). Running less than max?		
Inlet vanes aligned in housing, actuator spanned, modulate smoothly and proportional to input signal and EMS readout.		
All dampers (OSA, RA, EA, etc.) stroke fully without binding and spans calibrated and BAS reading site verified (follow procedure in Calibration and Leak-by Test Procedures). List dampers checked: _____		
Valves stroke fully and easily and spanning is calibrated (follow procedure in Calibration and Leak-by Test Procedures). List each actuated valve here when spanned: _____		
Valves verified to not be leaking through coils when closed at normal operating pressure (follow procedure in Calibration and Leak-by Test Procedures).		
The HOA switch properly activates and deactivates the unit		
Safeties installed and safe operating ranges for this equipment provided to the commissioning agent		
Specified sequences of operation and operating schedules have been implemented with all variations documented		
Specified point-to-point checks have been completed and documentation record submitted for this system		
Startup report completed with this checklist attached		

- *The checklist items of Part 3 are all successfully completed for given trade.* **YES** **NO**

Comments:

1. _____
2. _____
3. _____
4. _____

END OF SECTION 01 91 13

SECTION 02 41 19 - SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Demolition and removal of selected portions of building or structure.
 - 2. Salvage of existing items to be reused or recycled.
 - 3. **Demolition and removal of selected site elements.**

1.3 RELATED REQUIREMENTS

- A. Section 011000 "Summary" for restrictions on use of the premises, Owner-occupancy requirements, and phasing requirements.
- B. Section 017300 "Execution" for cutting and patching procedures.
- C. Comply with requirements in Section 013516 "Alteration Project Procedures."

1.4 DEFINITIONS

- A. Remove: Detach items from existing construction and dispose of them off-site unless indicated to be salvaged or reinstalled.
- B. Remove and Salvage: Detach items from existing construction, in a manner to prevent damage, and deliver to Owner ready for reuse or store.
- C. Remove and Reinstall: Detach items from existing construction, in a manner to prevent damage, prepare for reuse, and reinstall where indicated.
- D. Existing to Remain: Leave existing items that are not to be removed and that are not otherwise indicated to be salvaged or reinstalled.
- E. Dismantle: To remove by disassembling or detaching an item from a surface, using gentle methods and equipment to prevent damage to the item and surfaces; disposing of items unless indicated to be salvaged or reinstalled.

1.5 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.
- B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
 - 1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.6 PREINSTALLATION MEETINGS

- A. Predemolition Conference: Conduct conference at Project site.
 - 1. Inspect and discuss condition of construction to be selectively demolished.
 - 2. Review structural load limitations of existing structure.
 - 3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - 4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
 - 5. Review areas where existing construction is to remain and requires protection.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For refrigerant recovery technician.
- B. Engineering Survey: Submit engineering survey of condition of building.
- C. Proposed Protection Measures: Submit report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.
- D. Schedule of selective demolition activities with starting and ending dates for each activity.
- E. Predemolition photographs or video.
- F. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.
- G. Warranties: Documentation indicating that existing warranties are still in effect after completion of selective demolition.

1.8 QUALITY ASSURANCE

- A. Refrigerant Recovery Technician Qualifications: Certified by an EPA-approved certification program.

1.9 FIELD CONDITIONS

- A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.
- B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
- C. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.
- D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
 - 1. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.
- E. Storage or sale of removed items or materials on-site is not permitted.
- F. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.
 - 1. Maintain fire-protection facilities in service during selective demolition operations.
- G. Arrange selective demolition schedule so as not to interfere with Owner's operations.

1.10 WARRANTY

- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials and using approved contractors so as not to void existing warranties.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- B. Standards: Comply with ASSE A10.6 and NFPA 241.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that utilities have been disconnected and capped before starting selective demolition operations.
- B. Perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective building demolition operations.
- C. Survey of Existing Conditions: Record existing conditions by use of preconstruction photographs or video.
 - 1. Comply with requirements specified in Section 013233 "Photographic Documentation."
 - 2. Inventory and record the condition of items to be removed and salvaged. Provide photographs or video of conditions that might be misconstrued as damage caused by salvage operations.

3.2 PREPARATION

- A. Refrigerant: Before starting demolition, remove refrigerant from mechanical equipment according to 40 CFR 82 and regulations of authorities having jurisdiction.

3.3 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

- A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
- B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.
 - 1. Arrange to shut off utilities with utility companies.
 - 2. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
 - 3. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated on Drawings to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

- e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
- g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material and leave in place.

3.4 PROTECTION

- A. Temporary Protection: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 - 1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
 - 2. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
 - 3. **Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.**
 - 4. **Cover and protect furniture, furnishings, and equipment that have not been removed.**
 - 5. **Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Section 015000 "Temporary Facilities and Controls."**
- B. Temporary Shoring: Design, provide, and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.
- C. Remove temporary barricades and protections where hazards no longer exist.

3.5 SELECTIVE DEMOLITION

- A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
 - 1. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.
 - 2. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
 - 3. Use of open-flame equipment is not permitted. Maintain portable fire-suppression devices during heat-generating equipment operations.
 - 4. Maintain fire watch during and for at least 2 hours after heat-generating equipment operations. Comply with requirements in Section 013516 "Alteration Project Procedures."

5. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
 6. Dispose of demolished items and materials promptly. Comply with requirements in Section 017419 "Construction Waste Management and Disposal."
- B. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
- C. Removed and Salvaged Items.
1. Clean salvaged items.
 2. Pack or crate items after cleaning. Identify contents of containers.
 3. Store items in a secure area until delivery to Owner.
 4. Transport items to Owner's storage area on-site.
 5. Protect items from damage during transport and storage.
- D. Removed and Reinstalled Items:
1. Clean and repair items to functional condition adequate for intended reuse.
 2. Pack or crate items after cleaning and repairing. Identify contents of containers.
 3. Protect items from damage during transport and storage.
 4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.
- E. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.
- 3.6 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS
- A. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals using power-driven saw, and then remove concrete between saw cuts.
- B. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, and then remove masonry between saw cuts.
- C. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI's "Recommended Work Practices for the Removal of Resilient Floor Coverings." Do not use methods requiring solvent-based adhesive strippers.
- D. **Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished, and then break up and remove.**

3.7 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove demolition waste materials from Project site and recycle or dispose of them according to Section 017419 "Construction Waste Management and Disposal."
 - 1. Do not allow demolished materials to accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
 - 3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
 - 4. Comply with requirements specified in Section 017419 "Construction Waste Management and Disposal."
- B. Burning: Do not burn demolished materials.

3.8 CLEANING

- A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION 02 41 19

SECTION 05 50 00 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Flat plate steel railings.
 - 2. Metal bollards.

1.3 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Metal bollards.
- B. Sustainable Design Submittals:
 - 1. [Product Data](#): For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. [Environmental product declaration](#).
 - 3. [Environmental Product Declaration \(EPD\)](#): For each product.
- C. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.
- D. Delegated-Design Submittal: For flat steel plate railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.5 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls, floor slabs, decks, and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design flat plate steel railings.
- B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. applied in any direction.
 - b. Concentrated load of 200 lbf applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.

2.2 METALS

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- C. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- D. Steel Pipe: ASTM A53/A53M, Standard Weight (Schedule 40) unless otherwise indicated.

2.3 FASTENERS

- A. Cast-in-Place Anchors in Concrete: Either threaded or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A47/A47M malleable iron or ASTM A27/A27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F2329/F2329M.
- B. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
 - 1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.

2.4 MISCELLANEOUS MATERIALS

- A. Shop Primers: Provide primers that comply with Section 099123 "Interior Painting."
- B. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

- C. Concrete: Comply with requirements for normal-weight, air-entrained concrete with a minimum 28-day compressive strength of 3000 psi.

2.5 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

2.6 STEEL RAILINGS

- A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.
- B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.
 - 1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

2.7 METAL BOLLARDS

- A. Fabricate metal bollards from galvanized Schedule 80 steel pipe.
- B. Fabricate bollards with 3/8-inch-thick, steel baseplates for bolting to concrete slab. Drill baseplates at all four corners for 3/4-inch anchor bolts.
- C. Prime steel bollards with zinc-rich primer.

2.8 GENERAL FINISH REQUIREMENTS

- A. Finish metal fabrications after assembly.

2.9 STEEL AND IRON FINISHES

- A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
- B. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
- C. Preparation for Shop Priming: Prepare surfaces to comply with SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
- D. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- C. Field Welding: Comply with the following requirements:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.

4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

3.2 INSTALLATION OF METAL BOLLARDS

- A. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.
- B. Anchor bollards in place with concrete footings. Center and align bollards in holes 3 inches above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.

3.3 REPAIRS

- A. Touchup Painting:
 1. Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION 05 50 00

SECTION 07 92 00 – JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Urethane joint sealants.
2. Mildew-resistant joint sealants.
3. Latex joint sealants.

B. Related Sections include the following:

1. Section 07 92 19 "Acoustical Joint Sealants" for sealing joints in sound-rated construction.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each joint-sealant product.

B. Sustainable Design Submittals:

1. [Product Data](#): For sealants, indicating VOC content.
2. [Laboratory Test Reports](#): For sealants, indicating compliance with requirements for low-emitting materials.

- C. Samples: For each kind and color of joint sealant required.

D. Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For each kind of joint sealant, for tests performed by manufacturer and witnessed by a qualified testing agency.
- B. Preconstruction Field-Adhesion-Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.
- C. Field-Adhesion-Test Reports: For each sealant application tested.
- D. Sample Warranties: For special warranties.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Product Testing: Test joint sealants using a qualified testing agency.
 - 1. Testing Agency Qualifications: Qualified according to ASTM C1021 to conduct the testing indicated.
- C. Mockups: Install sealant in mockups of assemblies specified in other Sections that are indicated to receive joint sealants specified in this Section. Use materials and installation methods specified in this Section.

1.7 FIELD CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
 - 2. When joint substrates are wet.
 - 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 - 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.8 WARRANTY

- A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.

- B. Special Manufacturer's Warranty: Manufacturer agrees to furnish joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.
- C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
 - 1. Movement of the structure caused by stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
 - 2. Disintegration of joint substrates from causes exceeding design specifications.
 - 3. Mechanical damage caused by individuals, tools, or other outside agents.
 - 4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 JOINT SEALANTS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- B. VOC Content: Sealants and sealant primers shall comply with the following:
 - 1. Architectural sealants shall have a VOC content of 250 g/L or less.
 - 2. Sealants and sealant primers for nonporous substrates shall have a VOC content of 250 g/L or less.
 - 3. Sealants and sealant primers for porous substrates shall have a VOC content of 775 g/L or less.
 - 4. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.2 URETHANE JOINT SEALANTS

- A. Urethane, S, NS, 25, NT: Single-component, nonsag, nontraffic-use, plus 25 percent and minus 25 percent movement capability, urethane joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:
 - a. Pecora Corporation; Dynatrol I-XL Hybrid.

- b. Sherwin-Williams Company (The); Loxon S1.
 - c. Tremco Incorporated; Dymonic 100.
- B. Urethane, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT.
- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:
 - a. Pecora Corporation; NR-201.
 - b. Tremco Incorporated; Vulkem 45 SSL.

2.3 MILDEW-RESISTANT JOINT SEALANTS

- A. Mildew-Resistant Joint Sealants: Formulated for prolonged exposure to humidity with fungicide to prevent mold and mildew growth.
- B. Silicone, Mildew Resistant, Acid Curing, S, NS, 25, NT: Mildew-resistant, single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, acid-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.
- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:
 - a. Pecora Corporation; Pecora 898NST.
 - b. Sherwin-Williams Company (The); White Lightning All Purpose Silicone Rubber.
 - c. Tremco Incorporated; Tremsil 200.

2.4 LATEX JOINT SEALANTS

- A. Acrylic Latex: Acrylic latex or siliconized acrylic latex, ASTM C834, Type OP, Grade NF.
- 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:
 - a. Pecora Corporation; AC-20.
 - b. Sherwin-Williams Company (The); 950A Siliconized Acrylic Latex Caulk.
 - c. Tremco Incorporated; Tremflex 834.

2.5 JOINT-SEALANT BACKING

- A. Sealant Backing Material, General: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C1330, Type C (closed-cell material with a surface skin), and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.6 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT (LEED)

- A. The contractor, subcontractors, and their personnel shall follow the procedures and practices for waste separation, collection and transport as defined in the contractor's "Waste Management Plan" as required by Division 01 Section "Construction Waste Management."

3.2 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 - 2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning

operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:

- a. Concrete.
 - b. Masonry.
 - c. Unglazed surfaces of ceramic tile.
3. Remove laitance and form-release agents from concrete.
 4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
 - a. Metal.
 - b. Glass.
 - c. Porcelain enamel.
 - d. Glazed surfaces of ceramic tile.
- B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.4 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 1. Do not leave gaps between ends of sealant backings.
 2. Do not stretch, twist, puncture, or tear sealant backings.
 3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:

1. Place sealants so they directly contact and fully wet joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

1. Remove excess sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
3. Provide concave joint profile per Figure 8A in ASTM C1193 unless otherwise indicated.

3.5 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.7 JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Interior joints in horizontal traffic surfaces **JS-1**.

1. Joint Locations:
 - a. Isolation joints in cast-in-place concrete slabs.
 - b. Control and expansion joints in tile flooring.
 - c. Other joints as indicated on Drawings.
2. Joint Sealant: Urethane, S, P, 25, T, NT.
3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.

B. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces **JS-2**.

1. Joint Locations:
 - a. Control and expansion joints on exposed interior surfaces of exterior walls.

- b. Tile control and expansion joints.
 - c. Vertical joints on exposed surfaces of unit masonry, concrete walls and partitions.
 - d. Insert other joints.
 - e. Other joints as indicated on Drawings.
2. Joint Sealant: Urethane, S, NS, 25, NT.
 3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.
- C. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces not subject to significant movement **JS-3**.
1. Joint Locations:
 - a. Control joints on exposed interior surfaces of exterior walls.
 - b. Perimeter joints between interior wall surfaces and frames of interior doors, windows and elevator entrances.
 - c. Other joints as indicated on Drawings.
 2. Joint Sealant: Acrylic latex.
 3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.
- D. Joint-Sealant Application: Mildew-resistant interior joints in vertical surfaces and horizontal nontraffic surfaces **JS-4**.
1. Joint Locations:
 - a. Joints between plumbing fixtures and adjoining walls, floors, and counters.
 - b. Tile control and expansion joints where indicated.
 - c. Other joints as indicated on Drawings.
 2. Joint Sealant: Silicone, mildew resistant, acid curing, S, NS, 25, NT.
 3. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.
- E. **Joint-Sealant Application: Exterior joints in horizontal traffic surfaces JS-5.**
1. **Joint Locations:**
 - a. **Isolation joints in cast-in-place concrete slabs.**
 - b. **Other joints as indicated on Drawings.**
 2. **Joint Sealant: Urethane, S, P, 25, T, NT.**
 3. **Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.**

END OF SECTION 07 92 00

SECTION 08 71 00 – DOOR HARDWARE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Commercial door hardware for the following:
 - a. Swinging doors.
 - b. Sliding doors.
 - c. Folding doors.
 - d. Other doors to the extent indicated.
- B. Related Sections include the following:
 - 1. Division 8 Section "Hollow Metal Doors and Frames"
 - 2. Division 8 Section "Flush Wood Doors"
 - 3. Division 8 Section "Aluminum-Framed Entrances and Storefronts"

1.3 SUBMITTALS

- A. Product Data: Include installation details, material descriptions, dimensions of individual components and profiles, and finishes.
- B. Shop Drawings: Details of electrified door hardware, indicating the following:
 - 1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring. Include the following:
 - a. System schematic.
 - b. Point-to-point wiring diagram.
 - c. Riser diagram.
 - d. Elevation of each door.
 - 2. Detail interface between electrified door hardware and access fire alarm, control, and security building control system.
- C. Samples for Initial Selection: Manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available for each type of door hardware indicated.

1. Samples will be returned to Contractor. Units that are acceptable and remain undamaged through submittal, review, and field comparison process may, after final check of operation, be incorporated into the Work, within limitations of keying requirements.

- D. Door Hardware Schedule: Prepared by or under the supervision of supplier, detailing fabrication and assembly of door hardware, as well as procedures and diagrams. Coordinate the final Door Hardware Schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
 1. Format: Comply with scheduling sequence and vertical format in DHI's "Sequence and Format for the Hardware Schedule."
 2. Organization: Organize the Door Hardware Schedule into door hardware sets indicating complete designations of every item required for each door or opening.
 - a. Organize door hardware sets in same order as in the Door Hardware Schedule at the end of Part 3.
 3. Content: Include the following information:
 - a. Type, style, function, size, label, hand, and finish of each door hardware item.
 - b. Manufacturer of each item.
 - c. Fastenings and other pertinent information.
 - d. Location of each door hardware set, cross-referenced to Drawings, both on floor plans and in door and frame schedule.
 - e. Explanation of abbreviations, symbols, and codes contained in schedule.
 - f. Mounting locations for door hardware.
 - g. Door and frame sizes and materials.
 - h. Description of each electrified door hardware function, including location, sequence of operation, and interface with other building control systems.
 - 1) Sequence of Operation: Include description of component functions that occur in the following situations: authorized person wants to enter; authorized person wants to exit; unauthorized person wants to enter; unauthorized person wants to exit.
 4. Submittal Sequence: Submit the final Door Hardware Schedule at earliest possible date, particularly where approval of the Door Hardware Schedule must precede fabrication of other work that is critical in the Project construction schedule. Include Product Data, Samples, Shop Drawings of other work affected by door hardware, and other information essential to the coordinated review of the Door Hardware Schedule.
 5. Submittal Sequence: Submit initial draft of final schedule along with essential Product Data to facilitate the fabrication of other work that is critical in the Project construction schedule. Submit the final Door Hardware Schedule after Samples, Product Data, coordination with Shop Drawings of other work, delivery schedules, and similar information has been completed and accepted.

- E. Keying Schedule: Prepared by or under the supervision of supplier, detailing Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations.

- F. Product Certificates: Signed by manufacturers of electrified door hardware certifying that products furnished comply with requirements.
 - 1. Certify that door hardware approved for use on types and sizes of labeled fire doors complies with listed fire door assemblies.
- G. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
 - 1. Include lists of completed projects with project names and addresses of architects and owners, and other information specified.
- H. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, indicating current products comply with requirements.
- I. Maintenance Data: For each type of door hardware to include in maintenance manuals specified in Division 1.
- J. Warranties: Special warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed door hardware similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Supplier Qualifications: Door hardware supplier with warehousing facilities in Project's vicinity and who is or employs a qualified Architectural Hardware Consultant, available during the course of the Work to consult with Contractor, Architect, and Owner about door hardware and keying.
 - 1. Electrified Door Hardware Supplier Qualifications: An experienced door hardware supplier who has completed projects with electrified door hardware similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance, and who is acceptable to manufacturer of primary materials.
 - a. Engineering Responsibility: Prepare data for electrified door hardware, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
 - 2. Scheduling Responsibility: Preparation of door hardware and keying schedules.
- C. Architectural Hardware Consultant Qualifications: A person who is currently certified by the Door and Hardware Institute as an Architectural Hardware Consultant and who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project.
 - 1. Electrified Door Hardware Qualifications: Experienced in providing consulting services for electrified door hardware installations.

- D. Source Limitations: Obtain each type and variety of door hardware from a single manufacturer, unless otherwise indicated.
1. Provide electrified door hardware from same manufacturer as mechanical door hardware, unless otherwise indicated. Manufacturers that are listed to perform electrical modifications, by a testing and inspecting agency acceptable to authorities having jurisdiction, are acceptable.
- E. Regulatory Requirements: Comply with provisions of the following:
1. Where indicated to comply with accessibility requirements, comply with Americans with Disabilities Act (ADA), "Accessibility Guidelines for Buildings and Facilities (ADAAG)," ANSI A117.1, FED-STD-795, "Uniform Federal Accessibility Standards," as follows:
 - a. Handles, Pulls, Latches, Locks, and other Operating Devices: Shape that is easy to grasp with one hand and does not require tight grasping, tight pinching, or twisting of the wrist.
 - b. Door Closers: Comply with the following maximum opening-force requirements indicated:
 - 1) Interior Hinged Doors: 5 lbf applied perpendicular to door.
 - 2) Sliding or Folding Doors: 5 lbf applied parallel to door at latch.
 - 3) Fire Doors: Minimum opening force allowable by authorities having jurisdiction.
 - c. Thresholds: Not more than 1/2 inch high, Not more than 3/4 inch high for exterior sliding doors. Bevel raised thresholds with a slope of not more than 1:2.
 2. NFPA 101: Comply with the following for means of egress doors:
 - a. Latches, Locks, and Exit Devices: Not more than 15 lbf to release the latch. Locks shall not require the use of a key, tool, or special knowledge for operation.
 - b. Delayed-Egress Locks: Lock releases within 15 seconds after applying a force not more than 15 lbf for not more than 3 seconds.
 - c. Door Closers: Not more than 30 lbf to set door in motion and not more than 15 lbf to open door to minimum required width.
 - d. Thresholds: Not more than 1/2 inch high.
 3. Electrified Door Hardware: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- F. Fire-Rated Door Assemblies: Provide door hardware for assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to NFPA 252.
1. Test Pressure: Test at atmospheric pressure.
- G. Keying Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Meetings." Incorporate keying conference decisions into final

keying schedule after reviewing door hardware keying system including, but not limited to, the following:

1. Function of building, flow of traffic, purpose of each area, degree of security required, and plans for future expansion.
 2. Preliminary key system schematic diagram.
 3. Requirements for key control system.
 4. Address for delivery of keys.
- H. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Meetings."
- I. All Electric Door Hardware shall be furnished and installed by the General Contractor. All Electric Door Hardware shall be wired by the Electrical Contractor. Both the Electrical & General Contractor shall meet and coordinate all work before proceeding.
- J. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Meetings." Review methods and procedures related to electrified door hardware including, but not limited to, the following:
1. Inspect and discuss electrical roughing-in and other preparatory work performed by other trades.
 2. Review sequence of operation for each type of electrified door hardware.
 3. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 4. Review required testing, inspecting, and certifying procedures.
- 1.5 DELIVERY, STORAGE, AND HANDLING
- A. Inventory door hardware on receipt and provide secure lock-up for door hardware delivered to Project site.
 - B. Tag each item with Door Number related to the final Approved Door Hardware Schedule, and include basic installation instructions with each item or package.
 - C. Deliver keys to manufacturer of key control system, or Owner as Directed.
 - D. Deliver keys to Owner by registered mail or overnight package service.
- 1.6 COORDINATION
- A. Coordinate layout and installation of recessed pivots and closers with floor construction. Cast anchoring inserts into concrete. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."
 - B. Templates: Obtain and distribute to the parties involved templates for doors, frames, and other work specified to be factory prepared for installing door hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

- C. Electrical System Roughing-in: Coordinate layout and installation of electrified door hardware with connections to power supplies, fire alarm system and detection devices, access control system, security system, and building control system.

1.7 WARRANTY

- A. General Warranty: Special warranties specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, the following:
 - 1. Structural failures including excessive deflection, cracking, or breakage.
 - 2. Faulty operation of operators and door hardware.
 - 3. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
- C. Warranty Period for Locksets: Ten, (10) years from date of Substantial Completion, unless otherwise indicated.
- D. Warranty Period for Manual Closers: Twenty Five, (25) years from date of Substantial Completion, unless otherwise indicated.
- E. Warranty Period for Exit Devices: Ten, (10) years from date of Substantial Completion, unless otherwise indicated.
- F. Warranty Period for Electrical Exit Devices: Two, (2) years from date of Substantial Completion, unless otherwise indicated.

1.8 MAINTENANCE SERVICE

- A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.
- B. Maintenance Service: Beginning at Substantial Completion, provide six months' full maintenance by skilled employees of door hardware Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper door hardware operation. Provide parts and supplies as used in the manufacture and installation of original products.
- C. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain door hardware and door hardware finishes.

PART 2 - PRODUCTS

2.1 SCHEDULED DOOR HARDWARE

- A. General: Provide door hardware for each door to comply with requirements in this Section, door hardware sets indicated in door and frame schedule, and the Door Hardware Schedule at the end of Part 3.
 - 1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and named manufacturer's products. Retain subparagraph below for electrified door hardware.
 - 2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
- B. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of door hardware are indicated in the Door Hardware Schedule at the end of Part 3. Products are identified by using door hardware designations, as follows:
 - 1. Named Manufacturer's Products: Product designation and manufacturer are listed for each door hardware type required for the purpose of establishing minimum requirements. Manufacturers' names are abbreviated in the Door Hardware Schedule.
 - 2. References to BHMA Standards: Provide products complying with these standards and requirements for description, quality, and function.

2.2 HINGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Butt Hinges:
 - a. Dormakaba / Stanley Hinge Company, Inc.
 - 2. Continuous Hinges:
 - a. Architectural Builders Hardware Mfg., Inc.
 - b. Dormakaba / Stanley Hinge Company, Inc.
 - c. Select Hinges, Inc.
- B. Standards: Comply with the following:
 - 1. Hinges ANSI/BHMA Standard A156.1 Grade 1
 - 2. Continuous Hinges ANSI/BHMA Standard A156.26 Grade 1
- C. Template Requirements: Except for hinges and pivots to be installed entirely (both leaves) into wood doors and frames, provide only template-produced units.
- D. Concealed bearings are made from engineered polymer material with PTFE and Aramid fiber; bearing is maintenance free, no oil, no grease.
- E. Butt hinges equipped with easily seated, non-rising pin. Hole in bottom of pin enables quick pin removal for ease of installation.

- F. Continuous hinge material to be 14 gauge, 304 stainless steel
- G. Continuous hinge steel pin to be .25 diameter, 304 stainless steel
- H. Continuous hinge exterior barrel diameter .438 (7/16)
- I. Continuous hinge knuckle to be 2", including split nylon bearing at each separation for a quiet, smooth, self-lubricating operation
- J. All hinges to carry Warnock Hersey Int. or UL for fire rated doors and frames up to 3 hours
- K. Continuous hinges to have Symmetrically templated hole pattern
- L. Continuous hinge to have a 10 year Warranty
- M. Hinge Weight: Unless otherwise indicated, provide the following:
 - 1. Supports weights up to 600lbs.
- N. Hinge Base Metal: Unless otherwise indicated, provide the following:
 - 1. Exterior Continuous Hinges: Stainless steel, with stainless-steel pin,
 - 2. Interior Continuous Hinges: Stainless steel, with stainless-steel pin.
 - 3. Continuous Hinges for Fire-Rated Assemblies: Stainless steel, with stainless-steel pin.
 - 4. Exterior Butt Hinges: Stainless Steel or Brass or Bronze
 - 5. Interior Butt Hinges: Steel or Brass or Bronze
- O. Hinge Options: Comply with the following where indicated in the Door Hardware Schedule or on Drawings:
 - 1. Hospital Tips: Slope ends of hinge barrel.
 - 2. Maximum Security Pin: Fix pin in hinge barrel after it is inserted.
 - 3. Nonremovable Pins: Provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for the following applications:
 - a. Outswinging exterior doors.
 - b. Outswinging corridor doors with locks.
- P. Continuous-Geared Aluminum Hinges: Minimum 0.120-inch-thick, hinge leaves with minimum overall width of 4 inches; fabricated to full height of door and frame. Finish components after milling and drilling are complete. Fabricate hinges to template screw locations.
- Q. All geared hinges to be heavy-gauge aluminum alloy with solid support blocks of self-lubricating DELRIN.
- R. All geared hinges to meet Dynamic and static load test for compliance with ANSI A156.1, (BHMA) for 350,000 cycles at 15 cycles per minute.
- S. Fasteners: Comply with the following:

1. Machine Screws: For metal doors and frames. Install into drilled and tapped holes.
2. Wood Screws: For wood doors and frames.
3. Threaded-to-the-Head Wood Screws: For fire-rated wood doors.
4. Screws: Phillips flat-head screws; machine screws drilled and tapped holes for metal doors, wood screws for wood doors and frames. Finish screw heads to match surface of hinges.

2.3 LOCKS AND LATCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Mechanical Locks and Latches:
 - a. Dormakaba / Best Locksets
- B. Standards: Comply with the following:
 1. Mortise Locks and Latches: BHMA A156.13.
- C. Mortise Locks: Stamped steel case with steel or brass parts; ANSI A156.13, Series 1000, BHMA Grade 1 Operational and Grade 2 Security and be UL Listed.
- D. Certified Products: Provide door hardware listed in the following BHMA directories:
 1. Mechanical Locks and Latches: BHMA's "Directory of Certified Locks & Latches."
 2. Electromagnetic Locks: BHMA's "Directory of Certified Electromagnetic & Delayed Egress Locks."
- E. Lock Trim: Comply with the following:
 1. Lever: Mortise Locks & Latches, Forged or Cast brass, bronze or stainless steel construction
 2. Dummy Trim: Match lever lock trim and escutcheons.
- F. Lock Functions: Function numbers and descriptions indicated in the Door Hardware Schedule comply with the following:
 1. Bored Locks: BHMA A156.2.
 2. Mortise Locks: BHMA A156.13.
- G. Lock Throw: Comply with testing requirements for length of bolts to comply with labeled fire door requirements, and as follows:
 1. Bored Locks: Minimum 9/16-inch latch bolt throw.
 2. Mortise Locks: Minimum 3/4-inch latch bolt throw.
 3. Deadbolts: Minimum 1-inch bolt throw.
- H. Backset: 2-3/4 inches, unless otherwise indicated.

- I. Mortise Locks & Latches shall have an anti-friction, 3/4-inch throw latch bolt with anti-friction piece made of self-lubricated stainless steel. Latch bolt with plastic insert and three-piece latch bolt are unacceptable on this project.
- J. Mortise Locks & Latches shall have levers to be operated with a roller bearing spindle hub mechanism.
- K. Cylindrical Locks & Latches to have solid shank with no opening for access to keyed lever keeper.

2.4 DOOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Flush Bolts:
 - a. Triangle Brass Manufacturing Company, Inc.
- B. Standards: Comply with the following:
 - 1. Automatic and Self-Latching Flush Bolts: BHMA A156.3.
 - 2. Manual Flush Bolts: BHMA A156.16.
- C. Flush Bolts: BHMA Grade 1, designed for mortising into door edge.
- D. Bolt Throw: Comply with testing requirements for length of bolts to comply with labeled fire door requirements, and as follows:
 - 1. Mortise Flush Bolts: Minimum 3/4-inch throw.

2.5 EXIT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Precision Manufacturing, Inc.
- B. Standard: BHMA A156.3.
 - 1. BHMA Grade: Grade 1
- C. Certified Products: Provide exit devices listed in BHMA's "Directory of Certified Exit Devices."
- D. Panic Exit Devices: Listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for panic protection, based on testing according to UL 305.
- E. Fire Exit Devices: Complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire and panic protection, based on testing according to UL 305 and NFPA 252.

- F. Exit device shall be “touch pad” type with a touch pad that shall extend a minimum of one half (1/2) of the door width.
- G. Exit device shall have a one-quarter (1/4) gap between the face of the door and the touch bar channel eliminating the need for shims or cutting away the glass molding.
- H. Exit device lock stile chassis shall be investment cast steel. Stamped steel units will not be accepted. All device latch bolts shall be stainless steel and shall be deadlocking type.
- I. Exit device strikes shall be adjustable type investment cast stainless steel.
- J. Exit device shall include sound reduction dampening for both depression and extension of the touch pad.
- K. Exit device end cap shall be all metal and secured with a bracket that interlocks both at the touch bar channel base and hinge side filler to prevent end cap “peel-back”.
- L. All exposed surfaces of the exit device housing shall be no less than 14 gauge brass or bronze; or no less than 16 gauge stainless steel. Aluminum housing type exit devices are not acceptable.
- M. Dummy Push Bar: Nonfunctioning push bar matching functional push bar.
 - 1. Operation: Rigid
- N. Outside Trim: Lever, Lever with cylinder, Pull, Pull with cylinder, material and finish to match locksets, unless otherwise indicated.
 - 1. Match design for locksets and latchsets, unless otherwise indicated.

2.6 CYLINDERS AND KEYING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cylinders:
 - a. Dormakaba / Best IC Cylinders
 - b. All cylinders shall be Cormax 7-pin interchangeable cores.
- B. Standards: Comply with the following:
 - 1. Cylinders: BHMA A156.5.
- C. Cylinder Grade: BHMA Grade 1, Cylinders: Manufacturer's standard tumbler type, constructed from brass or bronze, stainless steel, or nickel silver, and complying with the following:
 - 1. Number of Pins: Seven.
 - 2. Mortise Type: Threaded cylinders with rings and straight- or clover-type cam.
 - 3. Rim Type: Cylinders with back plate, flat-type vertical or horizontal tailpiece, and raised trim ring.

4. Bored-Lock Type: Cylinders with tailpieces to suit locks.
- D. Permanent Cores: Manufacturer's standard; finish face to match lockset; complying with the following:
 1. Removable Cores: Core insert, removable by use of a special key, and for use with only the core manufacturer's locksets.
- E. Construction Keying: Comply with the following:
 1. Construction Cores: Provide Brass construction cores in all locksets and cylinders that are replaceable by permanent cores.
 - a. Replace Brass construction cores with permanent cores, as indicated in keying schedule
- F. Keying System: Unless otherwise indicated, provide a factory-registered keying system complying with the following requirements:
 1. No Master Key System: Cylinders are operated by change keys only.
 2. Master Key System: Cylinders are operated by a change key and a master key.
 3. Grand Master Key System: Cylinders are operated by a change key, a master key, and a grand master key.
 4. Great-Grand Master Key System: Cylinders are operated by a change key, a master key, a grand master key, and a great-grand master key.
 5. Existing System: Master key or grand master key locks to Owner's existing system.
 6. Keyed Alike: Key all cylinders to the same change key.
- G. Keys: Provide nickel-silver keys complying with the following:
 1. Stamping: Permanently inscribe each key with a visual key control number and include the following notation:
 - a. Notation: **"DO NOT DUPLICATE."**
 2. Quantity: In addition to one extra blank key for each lock, provide the following:
 - a. Cylinder Change Keys: Three.
 - b. Master Keys: Five.
 - c. Grand Master Keys: Five.
 - d. Great-Grand Master Keys: Five.
 - e. Control Keys: Five
 - f. Construction Master Keys: Ten
 - g. Construction Core Control Keys: Five

2.7 STRIKES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Electric Strikes:
 - a. RCI Manufacturing, Inc.
 - b. Dormakaba, Inc.

B. Standards: Comply with the following:

1. Strikes for Mortise Locks and Latches: BHMA A156.13.
2. Dustproof Strikes: BHMA A156.16.
3. Electric Strikes: BHMA A156.5.

C. Strikes: Provide manufacturer's standard strike with strike box for each latch or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, unless otherwise indicated, and as follows:

1. Flat-Lip Strikes: For locks with three-piece antifriction latch bolts, as recommended by manufacturer.
2. Extra-Long-Lip Strikes: For locks used on frames with applied wood casing trim.
3. Aluminum-Frame Strike Box: Provide manufacturer's special strike box fabricated for aluminum framing.

D. Dustproof Strikes: BHMA Grade 1

E. Electric Strikes: BHMA Grade 1

2.8 ACCESSORIES FOR PAIRS OF DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Coordinators:
 - a. Triangle Brass Manufacturing Company, Inc.
 - b. Burns Manufacturing Company, Inc.

2. Astragals:

- a. Architectural Builders Hardware, Inc.

B. Standards: Comply with the following:

1. Coordinators: BHMA A156.3.
2. Removable Mullions: BHMA A156.3.

2.9 CLOSERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Surface-Mounted Closers:

- a. Dormakaba USA, Inc.
 - B. Standards: Comply with the following:
 - 1. Closers: BHMA A156.4.
 - C. Surface Closers: BHMA Grade 1
 - D. Certified Products: Provide door closers listed in BHMA's "Directory of Certified Door Closers."
 - E. Size of Units: Unless otherwise indicated, comply with manufacturer's written recommendations for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.
- 2.10 PROTECTIVE TRIM UNITS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Metal Protective Trim Units:
 - a. Triangle Brass Manufacturing Company, Inc.
 - b. Burns Manufacturing Company, Inc.
 - B. Standard: Comply with BHMA A156.6.
 - C. Materials: Fabricate protection plates from the following:
 - 1. Stainless Steel: 0.050 inch thick; beveled 4 sides.
 - D. Fasteners: Provide manufacturer's standard exposed fasteners for door trim units consisting of either machine or self-tapping screws.
 - E. Furnish protection plates sized 2" less than door width on push side and 1" less than door width on pull side, by height specified in Door Hardware Schedule.
- 2.11 STOPS AND HOLDERS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Architectural Builders Hardware Mfg., Inc.
 - 2. Triangle Brass Manufacturing Company, Inc.
 - B. Standards: Comply with the following:
 - 1. Stops and Bumpers: BHMA A156.16.
 - 2. Mechanical Door Holders: BHMA A156.16.

3. Electromagnetic Door Holders: BHMA A156.15.
4. Combination Overhead Holders and Stops: BHMA A156.8.
5. Door Silencers: BHMA A156.16.

C. Stops and Bumpers: BHMA Grade 1

D. Mechanical Door Holders: BHMA Grade 1

E. Combination Overhead Stops and Holders: BHMA Grade 1

F. Electromagnetic Door Holders for Labeled Fire Door Assemblies: Coordinate with fire detectors and interface with fire alarm system.

G. Silencers for Metal Door Frames: BHMA Grade 1; neoprene or rubber, minimum diameter 1/2 inch; fabricated for drilled-in application to frame.

2.12 DOOR GASKETING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Door Gasketing:

- a. Reese Manufacturing Co., Inc.
- b. National Guard Products, Inc.

2. Door Bottoms:

- a. Reese Manufacturing Co., Inc.
- b. National Guard Products

B. Standard: Comply with BHMA A156.22.

C. General: Provide continuous weather-strip gasketing on exterior doors and provide smoke, light, or sound gasketing on interior doors where indicated or scheduled. Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.

1. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.
2. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.
3. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

D. Air Leakage: Not to exceed 0.50 cfm per foot of crack length for gasketing other than for smoke control, as tested according to ASTM E 283.

E. Smoke-Labeled Gasketing: Assemblies complying with NFPA 105 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for smoke-control ratings indicated, based on testing according to UL 1784.

1. Provide smoke-labeled gasketing on 20-minute-rated doors and on smoke-labeled doors.

- F. Fire-Labeled Gasketing: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to UL 10B or NFPA 252.
- G. Sound-Rated Gasketing: Assemblies that are listed and labeled by a testing and inspecting agency, for sound ratings indicated, based on testing according to ASTM E 1408.
- H. Replaceable Seal Strips: Provide only those units where resilient or flexible seal strips are easily replaceable and readily available from stocks maintained by manufacturer.
- I. Gasketing Materials: Comply with ASTM D 2000 and AAMA 701/702.

2.13 THRESHOLDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Reese Manufacturing Co., Inc.
 - 2. National Guard Products, Inc.
- B. Standard: Comply with BHMA A156.21.

2.14 FABRICATION

- A. Manufacturer's Nameplate: Do not provide manufacturers' products that have manufacturer's name or trade name displayed in a visible location (omit removable nameplates) except in conjunction with required fire-rated labels and as otherwise approved by Architect.
 - 1. Manufacturer's identification will be permitted on rim of lock cylinders only.
- B. Base Metals: Produce door hardware units of base metal, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18 for finishes. Do not furnish manufacturer's standard materials or forming methods if different from specified standard.
- C. Fasteners: Provide door hardware manufactured to comply with published templates generally prepared for machine, wood, and sheet metal screws. Provide screws according to commercially recognized industry standards for application intended. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.
 - 1. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.
 - 2. Steel Machine or Wood Screws: For the following fire-rated applications:
 - a. Mortise hinges to doors.

- b. Strike plates to frames.
 - c. Closers to doors and frames.
3. Steel Through Bolts: For the following fire-rated applications, unless door blocking is provided:
- a. Surface hinges to doors.
 - b. Closers to doors and frames.
 - c. Surface-mounted exit devices.
4. Spacers or Sex Bolts: For through bolting of hollow metal doors.
5. Fasteners for Wood Doors: Comply with requirements of DHI WDHS.2, "Recommended Fasteners for Wood Doors."

2.15 FINISHES

- A. Standard: Comply with BHMA A156.18.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- D. BHMA Designations: Comply with base material and finish requirements indicated by the following:
 - 1. BHMA 600: Primed for painting, over steel base metal.
 - 2. BHMA 626: Satin chromium plated over nickel, over brass or bronze base metal.
 - 3. BHMA 628: Satin aluminum, clear anodized, over aluminum base metal.
 - 4. BHMA 630: Satin stainless steel, over stainless steel base metal.
 - 5. BHMA 652: Satin chromium plated over nickel, over steel base metal.
 - 6. BHMA 689: Aluminum painted, over any base metal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.
- B. Examine roughing-in for electrical power systems to verify actual locations of wiring connections before electrified door hardware installation.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Steel Doors and Frames: Comply with DHI A115 series.
 - 1. Surface-Applied Door Hardware: Drill and tap doors and frames according to SDI 107.
- B. Wood Doors: Comply with DHI A115-W series.

3.3 INSTALLATION

- A. Mounting Heights: Mount door hardware units at heights indicated in following applicable publications, unless specifically indicated or required to comply with governing regulations:
 - 1. Standard Steel Doors and Frames: DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
 - 2. Custom Steel Doors and Frames: DHI's "Recommended Locations for Builders' Hardware for Custom Steel Doors and Frames."
 - 3. Wood Doors: DHI WDHS.3, "Recommended Locations for Architectural Hardware for Wood Flush Doors."
- B. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 9 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.
 - 1. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
 - 2. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
- C. Key Control System: Place keys on markers and hooks in key control system cabinet, as determined by final keying schedule. Supply key cabinet with 25% expansion. Factory install keys in cabinet or in field with owner's representative. Key cabinet to be supplied with a "Complete System" equal to the Telkee System.
- D. Boxed Power Supplies: Locate power supplies as indicated or, if not indicated, above accessible ceilings, in equipment room. Verify location with Architect.
 - 1. Configuration: Provide one power supply for each door opening.
 - 2. Configuration: Provide the least number of power supplies required to adequately serve doors with electrified door hardware.
- E. Thresholds: Set thresholds for exterior and acoustical doors in full bed of sealant complying with requirements specified in Division 7 Section "Joint Sealants."

3.4 FIELD QUALITY CONTROL

- A. Independent Architectural Hardware Consultant: Owner or Architect will engage a qualified independent Architectural Hardware Consultant to perform inspections and to prepare inspection reports.
 - 1. Independent Architectural Hardware Consultant will inspect door hardware and state in each report whether installed work complies with or deviates from requirements, including whether door hardware is properly installed and adjusted.

3.5 ADJUSTING

- A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
 - 1. Spring Hinges: Adjust to achieve positive latching when door is allowed to close freely from an open position of 30 degrees.
 - 2. Electric Strikes: Adjust horizontal and vertical alignment of keeper to properly engage lock bolt.
 - 3. Door Closers: Adjust sweep period so that, from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.
- B. Six-Month Adjustment: Approximately six months after date of Substantial Completion, Installer shall perform the following:
 - 1. Examine and readjust each item of door hardware as necessary to ensure function of doors, door hardware, and electrified door hardware.
 - 2. Consult with and instruct Owner's personnel on recommended maintenance procedures.
 - 3. Replace door hardware items that have deteriorated or failed due to faulty design, materials, or installation of door hardware units.

3.6 CLEANING AND PROTECTION

- A. Clean adjacent surfaces soiled by door hardware installation.
- B. Clean operating items as necessary to restore proper function and finish.
- C. Provide final protection and maintain conditions that ensure door hardware is without damage or deterioration at time of Substantial Completion.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain door hardware and door hardware finishes.

Addendum No. 1

3.8 DOOR HARDWARE SCHEDULE

Hardware Set #: 0001 - PRS DRS HMD & HMF LABEL
08-006.1 09-006.1 10-006.1

Opening to Have:

Qty Description	Finish	Mfg
6 HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
1 AUTOMATIC FLUSH BOLTS 3810 x 3850 (TOP ONLY)	630	TRIMCO
1 DUMMY TRIM 45H0-1DT-14H	630	BEST
1 ELECTRIC LOCKSET 45HW7-DEU-14H-RQE x C x ABC x CORMAX	630	BEST
1 ASTRAGAL A548B x BEVEL EDGE x FULL HEIGHT	630	ABH
1 POWER TRANSFER PT1000 x EZ	628	ABH
1 DOOR CLOSER / COORDINATOR TS9315 x GSR/PT x LSN x MK397	689	DORMAKABA
1 WIRE HARNESS WH-32"		STANLEY
1 WIRE HARNESS WH-192"		STANLEY
1 WIRE HARNESS WH-6E"		STANLEY
2 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK x ULS	630	TRIMCO
1 TEAR DROP SEAL 797B x HEAD & JAMBS	BLK	REESE
1 TEAR DROP SEAL 797B x ASTRAGAL x FULL HEIGHT	BLK	REESE
2 DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1 CARD READER BY SECURITY CONTRACTOR		

Hardware Set #: 0002 - SGL DRS WD & ALUM FR
08-013.1 08-024.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 OFFICE LOCKSET 45H7-A-14H-LESS STK x ABC x CORMAX	630	BEST
1 EXTENDED STRIKE LIP REQUIRED FOR ALUMINUM FRAME	630	ROCKWOOD
1 O/H CONCEALED STOP N1012A x HO (30" TO 36" DR)	630	ABH

Hardware Set #: 0003 - SGL DRS HMD & HMF (STC50)
08-021.1

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 OFFICE LOCKSET 45H7-A-14H x ABC x CORMAX	630	BEST
1 WALL STOP 1270WV	630	TRIMCO
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 AUTOMATIC DOOR BOTTOM BY STC DOOR MANUFACTURER		

Addendum No. 1

THE CITY OF PHILADELPHIA
Office of Emergency Management

Hardware Set #: 0004 - SGL DRS WD & ALUM FR
08-017.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 CLASSROOM LOCKSET 45H7-R-14H-LESS STK x ABC x CORMAX	630	BEST
1 EXTENDED STRIKE LIP REQUIRED FOR ALUMINUM FRAME	630	ROCKWOOD
1 O/H CONCEALED STOP N1012A x HO (30" TO 36" DR)	630	ABH

Hardware Set #: 0005 - SGL DRS WD & ALUM FR
08-011.1 ~~08-016.1~~ **09-011.1**

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 CLASSROOM LOCKSET 45H7-R-14H-LESS STK x ABC x CORMAX	630	BEST
1 EXTENDED STRIKE LIP REQUIRED FOR ALUMINUM FRAME	630	ROCKWOOD
1 WALL STOP 1270WV	630	TRIMCO

Hardware Set #: 0006 - SGL DRS WD & ALUM FR
08-012.1 08-025.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 PASSAGE LATCHSET 45H0-N-14H-LESS STK	630	BEST
1 EXTENDED STRIKE LIP REQUIRED FOR ALUMINUM FRAME	630	ROCKWOOD
1 WALL STOP 1270WV	630	TRIMCO

Hardware Set #: 0007 - SGL DRS WD & HMF
09-002.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
1 RIM CYLINDER (IC) 1E72 x RP x ABC x CORMAX	626	BEST
1 POWER TRANSFER PT1000 x EZ	628	ABH
1 POWER SUPPLY RPSMLR2	600	PRECISION
1 RIM EXIT DEVICE MLR-TS-C-2103 x 4903D x S301	630	PRECISION
1 DOOR CLOSER TS9315 x PT x CS	689	DORMAKABA
1 WIRE HARNESS WH-26"		STANLEY
1 WIRE HARNESS WH-192"		STANLEY
1 WIRE HARNESS WH-6E"		STANLEY
1 WALL STOP 1270WV	630	TRIMCO
1 DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1 CARD READER BY SECURITY CONTRACTOR		

Addendum No. 1

**THE CITY OF PHILADELPHIA
Office of Emergency Management**

Hardware Set #: 0008 - PRS DRS WD & HMF (UNEQUAL PAIR)
09-002.2

Opening to Have:

Qty	Description	Finish	Mfg
6	HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
2	FLUSH BOLT 3917 1" x 6-3/4" x 12"	626	TRIMCO
1	DUST PROOF STRIKE 3910	630	TRIMCO
1	ASTRAGAL A548B x BEVEL EDGE x FULL HEIGHT	630	ABH
1	POWER TRANSFER PT1000 x EZ	628	ABH
1	POWER SUPPLY RPSMLR2	600	PRECISION
1	MORTISE EXIT DEVICE MLR-TS-LS-C-2303 x VM4908D x S983	630	PRECISION
1	DOOR CLOSER TS9315 x PT x CS	689	DORMAKABA
1	WIRE HARNESS WH-26"		STANLEY
1	WIRE HARNESS WH-192"		STANLEY
1	WIRE HARNESS WH-6E"		STANLEY
1	WALL STOP 1270WV	630	TRIMCO
2	DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1	CARD READER BY SECURITY CONTRACTOR		

Hardware Set #: 0009 - SGL DRS WD & HMF
09-013.1

Opening to Have:

Qty	Description	Finish	Mfg
3	HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
1	STOREROOM LOCKSET 45H7-D-14H x ABC x CORMAX	630	BEST
1	DOOR CLOSER TS9315 x PT x CS	689	DORMAKABA
1	WALL STOP 1270WV	630	TRIMCO
1	TEAR DROP SEAL 797B x HEAD & JAMBS	BLK	REESE
1	AUTOMATIC DOOR BOTTOM 330C x FULL WIDTH	628	REESE
1	THRESHOLD 2145-SS x FHSL x FULL WIDTH	630	REESE
1	DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1	ELECTRIC STRIKE ES74F x 24VDC	630	DORMAKABA
1	CARD READER BY SECURITY CONTRACTOR		

~~Hardware Set #: 0010 - SGL DRS WD & HMF
09-013.2~~

~~Opening to Have:~~

Qty	Description	Finish	Mfg
3	HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
1	OFFICE LOCKSET 45H7-A-14H x ABC x CORMAX	630	BEST
1	DOOR CLOSER TS9315 x PTH x CS	689	DORMAKABA
1	TEAR DROP SEAL 797B x HEAD & JAMBS	BLK	REESE
1	AUTOMATIC DOOR BOTTOM 330C x FULL WIDTH	628	REESE
1	THRESHOLD 2145-SS x FHSL x FULL WIDTH	630	REESE

Hardware Set #: 0010 - SGL DRS HMD & HMF (STC50 x 2-1/2" THICK DOOR)
09-013.2

Opening to Have:

<u>Qty</u>	<u>Description</u>	<u>Finish</u>	<u>Mfg</u>
<u>3</u>	<u>CAM LIFT HINGES BY STC DOOR MANUFACTURER</u>		
<u>1</u>	<u>OFFICE LOCKSET 45H7-A-14H x ABC x CORMAX x 2-1/2" THICK DR</u>	<u>630</u>	<u>BEST</u>
<u>1</u>	<u>DOOR CLOSER TS9315 x PTH x CS</u>	<u>689</u>	<u>DORMAKABA</u>
<u>1</u>	<u>THRESHOLD BY STC DOOR MANUFACTURER</u>		
<u>1</u>	<u>SOUND SEALS BY STC DOOR MANUFACTURER</u>		
<u>1</u>	<u>BOOT SEAL BY STC DOOR MANUFACTURER</u>		

Addendum No. 1

THE CITY OF PHILADELPHIA
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Hardware Set #: 0011 - SGL DRS WD & HMF
09-015.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CBI68 4.5 x 4.5	652	STANLEY
1 STOREROOM LOCKSET 45H7-D-14H x ABC x CORMAX	630	BEST
1 DOOR CLOSER TS9315 x T x CS	689	DORMAKABA
1 WALL STOP 1270WV	630	TRIMCO
1 TEAR DROP SEAL 797B x HEAD & JAMBS	BLK	REESE
1 AUTOMATIC DOOR BOTTOM 330C x FULL WIDTH	628	REESE
1 THRESHOLD 2145-SS x FHSL x FULL WIDTH	630	REESE
1 DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1 ELECTRIC STRIKE ES74F x 24VDC	630	DORMAKABA
1 CARD READER BY SECURITY CONTRACTOR		

Hardware Set #: 0012 - SGL DRS HMD & HMF (STC50 x 2-1/2" THICK DOOR)
09-016.1 09-016.2

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 STOREROOM LOCKSET 45H7-D-14H-ABC x CORMAX <u>x 2-1/2" THICK DR</u>	630	BEST
1 DOOR CLOSER 8916FC x AF89J x LSN	689	DORMAKABA
1 WALL STOP 1270WV	630	TRIMCO
1 DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1 ELECTRIC STRIKE ES74F x 24VDC	630	DORMAKABA
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 <u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		
1 CARD READER BY SECURITY CONTRACTOR		
1 PASSIVE INFRARED BY SECURITY CONTRACTOR		

Hardware Set #: 0013 - SGL DRS WD & HMF
09-017.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CBI68 4.5 x 4.5 x NRP	652	STANLEY
1 CLASSROOM LOCKSET 45H7-R-14H-7/8 x ABC x CORMAX	630	BEST
1 DOOR CLOSER TS9315 x PT x CS	689	DORMAKABA
1 TOUCHLESS SWITCH 910TC		RCI
1 WALL STOP 1270WV	630	TRIMCO
3 SILENCERS 1229A	GRAY	TRIMCO
1 DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1 EMERGENCY PULL STATION 39043B	BLUE	DORMAKABA
1 ELECTROMAGNETIC LOCK EML310 x 24VDC	628	DORMAKABA
1 CARD READER BY SECURITY CONTRACTOR		
1 PASSIVE INFRARED BY SECURITY CONTRACTOR		

Addendum No. 1

THE CITY OF PHILADELPHIA
Office of Emergency Management

Hardware Set #: 0014 - SGL DRS HMD & HMF (STC52 x 2-1/2" THICK DOOR)
09-015.2

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 OFFICE LOCKSET 45H7-A-14H x ABC x CORMAX <u>x 2-1/2" THICK DR</u>	630	BEST
1 DOOR CLOSER 8916FC x AF89J x LSN	689	DORMAKABA
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 FLOOR STOP 1211 x MS/ES	613	TRIMCO
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 <u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		

Hardware Set #: 0015 - SGL DRS HMD & HMF (STC52 x 2-1/2" THICK DOOR)
09-017.2

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 OFFICE LOCKSET 45H7-A-14H x ABC x CORMAX <u>x 2-1/2" THICK DR</u>	630	BEST
1 DOOR CLOSER 8916FC x AF89J x LSN	689	DORMAKABA
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 FLOOR STOP 1211 x MS/ES	630	TRIMCO
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 <u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		

Hardware Set #: 0016 - SGL DRS WD & ALUM FR
09-012.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 CLASSROOM LOCKSET 45H7-R-14H-LESS STK x ABC x CORMAX	630	BEST
1 EXTENDED STRIKE LIP REQUIRED FOR ALUMINUM FRAME	630	ROCKWOOD
1 DOOR CLOSER TS9315 x T x CS	689	DORMAKABA
1 O/H CONCEALED STOP N1022A x STOP (30" TO 36" DR)	630	ABH

Addendum No. 1

THE CITY OF PHILADELPHIA
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Hardware Set #: 0017 - PRS DRS HMD & HMF (UNEQUAL PAIR)
10-012.1

Opening to Have:

Qty	Description	Finish	Mfg
6	HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
2	FLUSH BOLT 3917 1" x 6-3/4" x 12"	626	TRIMCO
1	DUST PROOF STRIKE 3910	630	TRIMCO
1	ELECTRIC LOCKSET 45HW7-DEU-14H-RQE-7/8 x C x ABC x CORMAX	630	BEST
1	ASTRAGAL A548B x BEVEL EDGE x FULL HEIGHT	630	ABH
1	POWER TRANSFER PT1000 x EZ	628	ABH
1	DOOR CLOSER 8916FC x SPAT x LSN	689	DORMAKABA
1	WIRE HARNESS WH-32"		STANLEY
1	WIRE HARNESS WH-192"		STANLEY
1	WIRE HARNESS WH-6E"		STANLEY
2	KICK PLATE 16" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
2	MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
2	WALL STOP 1270WV	630	TRIMCO
2	SILENCERS 1229A	GRAY	TRIMCO
2	DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1	DOOR TO SWING 140 DEGREES		
1	CARD READER BY SECURITY CONTRACTOR		

Hardware Set #: 0018 - PRS DRS WD & HMF (UNEQUAL PAIR)
10-013.1

Opening to Have:

Qty	Description	Finish	Mfg
6	HINGE CB168 4.5 x 4.5	652	STANLEY
2	FLUSH BOLT 3917 1" x 6-3/4" x 12"	626	TRIMCO
1	DUST PROOF STRIKE 3910	630	TRIMCO
1	CLASSROOM LOCKSET 45H7-R-14H-7/8 x ABC x CORMAX	630	BEST
1	DUMMY TRIM 45H0-2DT-14H	630	BEST
1	ASTRAGAL A548B x BEVEL EDGE x FULL HEIGHT	630	ABH
1	DOOR CLOSER TS9315 x T x CS	689	DORMAKABA
1	TOUCHLESS SWITCH 910TC		RCI
2	WALL STOP 1270WV	630	TRIMCO
2	SILENCERS 1229A	GRAY	TRIMCO
2	DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1	EMERGENCY PULL STATION 39043B	BLUE	DORMAKABA
1	ELECTROMAGNETIC LOCK EML310 x 24VDC	628	DORMAKABA
1	CARD READER BY SECURITY CONTRACTOR		
1	PASSIVE INFRARED BY SECURITY CONTRACTOR		

Hardware Set #: 0019 - SGL DRS HMD & HMF (STC52 **x 2-1/2" THICK DOOR**)
10-014.1 ~~10-014.2~~ 10-015.1 ~~10-015.2~~

Opening to Have:

Qty	Description	Finish	Mfg
3	CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1	CLASSROOM LOCKSET 45H7-R-14H-ABC x CORMAX x 2-1/2" THICK DR	630	BEST
1	MORTISE CYLINDER (IC) 1E74 x C4 x RP3 x ABC x CORMAX	626	BEST
1	RIM CYLINDER (IC) 1E72 x RP x ABC x CORMAX	626	BEST
1	RIM EXIT DEVICE 2108CD x V4908D	630	PRECISION
1	DOOR CLOSER 8916FC x SDST x PD x LSN	689	DORMAKABA
1	KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1	MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1	THRESHOLD BY STC DOOR MANUFACTURER		
1	SOUND SEALS BY STC DOOR MANUFACTURER		
1	<u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		

Addendum No. 1

**THE CITY OF PHILADELPHIA
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Hardware Set #: 0020 - PRS DRS WD (POCKET DOORS)
10-018.1

Opening to Have:

Qty Description	Finish	Mfg
2 MORTISE CYLINDER (IC) 1E74 x C4 x RP3 x ABC x CORMAX	626	BEST
1 POCKET DOOR JOINER KIT CPD x CC x DOUBLE DOOR JOINER		KNC
1 DOOR EDGE PULL C-21-BB	630	KNC
2 POCKET DOOR KIT TYPE CC-3HD		KNC
1 LOCKSET C-90L-CC	630	KNC

Hardware Set #: 0021 - SGL DRS WD & HMF
10-020.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 PRIVACY LOCKSET 45H0-L-14H x VIB	630	BEST
1 DOOR CLOSER TS9315 x T x CS	689	DORMAKABA
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 WALL STOP 1270WV	630	TRIMCO
1 TEAR DROP SEAL 797B x HEAD & JAMBS	BLK	REESE

Hardware Set #: 0022 - PRS DRS HMD & HMF
10-021.1

Opening to Have:

Qty Description	Finish	Mfg
6 HINGE CB168 4.5 x 4.5	652	STANLEY
2 FLUSH BOLT 3917 1" x 6-3/4" x 12"	626	TRIMCO
1 DUST PROOF STRIKE 3910	630	TRIMCO
1 ELECTRIC LOCKSET 45HW7-DEU-14H-RQE-7/8 x C x ABC x CORMAX	630	BEST
1 ASTRAGAL A548B x BEVEL EDGE x FULL HEIGHT	630	ABH
1 POWER TRANSFER PT1000 x EZ	628	ABH
1 DOOR CLOSER TS9315 x TH x CS	689	DORMAKABA
1 WIRE HARNESS WH-32"		STANLEY
1 WIRE HARNESS WH-192"		STANLEY
1 WIRE HARNESS WH-6E"		STANLEY
2 KICK PLATE 16" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
2 SILENCERS 1229A	GRAY	TRIMCO
2 DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1 DOOR TO SWING 180 DEGREES		
1 CARD READER BY SECURITY CONTRACTOR		

Hardware Set #: 0023 - PRS DRS WD & ALUM FR
10-016.1

Opening to Have:

Qty Description	Finish	Mfg
6 HINGE CB168 4.5 x 4.5	652	STANLEY
1 FLUSH BOLT 3917 1" x 6-3/4" x 12" x TOP ONLY	626	TRIMCO
2 MORTISE CYLINDER (IC) 1E74 x C181 x RP3 x ABC x CORMAX	626	BEST
1 DEADBOLT (SWINGING DOOR) MS1850S	628	ADAMS-RITE
4 DOOR PULL AP314 x G x 74 x S x 4 x N	710	TRIMCO
2 DOOR CLOSER TS9315 x TH x CS	689	DORMAKABA
2 O/H CONCEALED STOP N1022A x STOP (30" TO 36" DR)	630	ABH

Addendum No. 1

THE CITY OF PHILADELPHIA
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Hardware Set #: 0024 - SGL DRS WD & ALUM FR
10-023.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 CLASSROOM LOCKSET 45H7-R-14H-LESS STK x ABC x CORMAX	630	BEST
1 EXTENDED STRIKE LIP REQUIRED FOR ALUMINUM FRAME	630	ROCKWOOD
1 DOOR CLOSER TS9315 x TH x CS	689	DORMAKABA
1 WALL STOP 1270WV	630	TRIMCO

Hardware Set #: 0025 - SGL DRS WD & HMF
10-025.1 10-026.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 PRIVACY LOCKSET 45H0-L-14H x VIB	630	BEST
1 DOOR CLOSER TS9315 x T x CS	689	DORMAKABA
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 WALL STOP 1270WV	630	TRIMCO
1 TEAR DROP SEAL 797B x HEAD & JAMBS	BLK	REESE

Hardware Set #: 0026 - SGL DRS WD & HMF
10-029.1 10-030.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB199 4.5 x 4.5	630	STANLEY
1 PRIVACY LOCKSET 45H0-L-14H x VIB	630	BEST
1 DOOR CLOSER TS9315 x T x CS	689	DORMAKABA
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 WALL STOP 1270WV	630	TRIMCO
1 TEAR DROP SEAL 797B x HEAD & JAMBS	BLK	REESE

Hardware Set #: 0027 - SGL DRS HMD & HMF (STC52 x 2-1/2" THICK DOOR)
10-031.1

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 PASSAGE LATCHSET 45H0-N-14H <u>x 2-1/2" THICK DR</u>	630	BEST
1 DOOR CLOSER 8916FC x AF89 (REG ARM MOUNT) x LSN	689	DORMAKABA
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 WALL STOP 1270WV	630	TRIMCO
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 <u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		

Addendum No. 1

THE CITY OF PHILADELPHIA
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Hardware Set #: 0028 - SGL DRS HMD & HMF (STC52 x 2-1/2" THICK DOOR)
10-031.2

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 PASSAGE LATCHSET 45H0-N-14H <u>x 2-1/2" THICK DR</u>	630	BEST
1 DOOR CLOSER 8916FC x SDS x PD x LSN	689	DORMAKABA
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 <u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		

Hardware Set #: 0029 - SGL DRS HMD & HMF
10-032.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 STOREROOM LOCKSET 45H7-D-14H x ABC x CORMAX	630	BEST
1 KICK PLATE 16" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 WALL STOP 1270WV	630	TRIMCO
3 SILENCERS 1229A	GRAY	TRIMCO

Hardware Set #: 0030 - SGL DRS HMD & HMF
10-022.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
1 ELECTRIC LOCKSET 45HW7-DEU-14H-RQE x C x ABC x CORMAX	630	BEST
1 DOOR CLOSER 8916FC x SPA x LSN	689	DORMAKABA
1 WIRE HARNESS WH-32"		STANLEY
1 WIRE HARNESS WH-192"		STANLEY
1 WIRE HARNESS WH-6E"		STANLEY
1 KICK PLATE 16" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 WALL STOP 1270WV	630	TRIMCO
3 SILENCERS 1229A	GRAY	TRIMCO
1 DOOR CONTACT MC-7 x SPDT x 1" DIA		DORMAKABA
1 DOOR TO SWING 180 DEGREES		
1 CARD READER BY SECURITY CONTRACTOR		

Hardware Set #: 0031 - SGL DRS WD & HMF
12-002.1

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5	652	STANLEY
1 STOREROOM LOCKSET 45H7-D-14H x ABC x CORMAX	630	BEST
1 KICK PLATE 10" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
1 WALL STOP 1270WV	630	TRIMCO
3 SILENCERS 1229A	GRAY	TRIMCO

Addendum No. 1

Hardware Set #: 0032 - SGL DRS HMD & HMF (STC45 **x 2-1/2" THICK DOOR**)
08-018.1

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 OFFICE LOCKSET 45H7-A-14H x ABC x CORMAX <u>x 2-1/2" THICK DR</u>	630	BEST
1 WALL STOP 1270WV	630	TRIMCO
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 <u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		

Hardware Set #: 0033 - SGL DRS HMD & HMF (STC50 **x 2-1/2" THICK DOOR**)
08-022.1 08-022.2

Opening to Have:

Qty Description	Finish	Mfg
3 CAM LIFT HINGES BY STC DOOR MANUFACTURER		
1 CLASSROOM LOCKSET 45H7-R-14H-ABC x CORMAX <u>x 2-1/2" THICK DR</u>	630	BEST
1 O/H CONCEALED STOP N1012A x HO (30" TO 36" DR)	630	ABH
1 THRESHOLD BY STC DOOR MANUFACTURER		
1 SOUND SEALS BY STC DOOR MANUFACTURER		
1 <u>BOOT SEAL</u> BY STC DOOR MANUFACTURER		

Hardware Set #: 0034 - SGL DRS HMD & HMF
10-012.2

Opening to Have:

Qty Description	Finish	Mfg
3 HINGE CB168 4.5 x 4.5 x NRP	652	STANLEY
1 CLASSROOM LOCKSET 45H7-R-14H x ABC x CORMAX	630	BEST
1 DOOR CLOSER 8916FC x SDST x LSN	689	DORMAKABA
1 KICK PLATE 16" x 2" LDW .050 x B4E x CTSK	630	TRIMCO
1 MOP PLATE 6" x 1" LDW .050 x B4E x CTSK	630	TRIMCO
3 SILENCERS 1229A	GRAY	TRIMCO

Hardware Set #: 0035 - SGL DRS HMD & HMF (STC45 x 2-1/2" THICK DOOR)
08-016.1

Opening to Have:

<u>Qty Description</u>	<u>Finish</u>	<u>Mfg</u>
<u>3 CAM LIFT HINGES BY STC DOOR MANUFACTURER</u>		
<u>1 CLASSROOM LOCKSET 45H7-R-14H-ABC x CORMAX x 2-1/2" THICK DR</u>	<u>630</u>	<u>BEST</u>
<u>1 WALL STOP 1270WV</u>	<u>630</u>	<u>TRIMCO</u>
<u>1 THRESHOLD BY STC DOOR MANUFACTURER</u>		
<u>1 SOUND SEALS BY STC DOOR MANUFACTURER</u>		
<u>1 BOOT SEAL BY STC DOOR MANUFACTURER</u>		

END OF SECTION 08 71 00

SECTION 10 14 25 - ROOM-IDENTIFICATION PANEL SIGNAGE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes room-identification signs that are directly attached to the building.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Product Data: For adhesives, indicating VOC content.
 - 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: For room-identification signs.
 - 1. Include fabrication and installation details and attachments to other work.
 - 2. Show sign mounting heights, locations of supplementary supports to be provided by other installers, and accessories.
 - 3. Show message list, typestyles, graphic elements, including raised characters and Braille, and layout for each sign at least half size.
- D. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

- A. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design" the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

2.2 ROOM-IDENTIFICATION SIGNS

- A. Room-Identification Sign: Sign system with smooth, uniform surfaces; with message and characters having uniform faces, sharp corners, and precisely formed lines and profiles; and as follows:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ACE Sign Systems, Inc.
 - b. APCO Graphics, Inc.
 - c. ASI Sign Systems, Inc.
 - d. Inpro Corporation.
 - 2. Laminated-Sheet Sign: Photopolymer face sheet with raised graphics laminated over subsurface graphics to acrylic backing sheet to produce composite sheet.
 - a. Composite-Sheet Thickness: Manufacturer's standard for size of sign.
 - b. Surface-Applied Graphics: Applied vinyl film, paint, and/or photo image.
 - c. Color(s): As selected by Architect from manufacturer's full range.
 - 3. Sign-Panel Perimeter: Finish edges smooth.
 - a. Edge Condition at Vertical Edges at Horizontal Edges: Square cut.
 - b. Corner Condition in Elevation: As indicated on Drawings.
 - 4. Mounting: Manufacturer's standard method for substrates indicated with concealed anchors or countersunk flathead through fasteners.

2.3 SIGN MATERIALS

- A. Acrylic Sheet: ASTM D4802, category as standard with manufacturer for each sign, Type UVF (UV filtering).
- B. Vinyl Film: UV-resistant vinyl film with pressure-sensitive, permanent adhesive; die cut to form characters or images as indicated on Drawings and suitable for exterior applications.

2.4 ACCESSORIES

- A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of signs, noncorrosive and compatible with each material joined, and complying with the following:
 - 1. Use concealed fasteners and anchors unless indicated to be exposed.
 - 2. For exterior exposure, furnish stainless-steel devices unless otherwise indicated.
 - 3. Exposed Metal-Fastener Components, General:
 - a. Fabricated from same basic metal and finish of fastened sign unless otherwise indicated.
 - 4. Sign Mounting Fasteners:
 - a. Concealed Studs: Concealed (blind), threaded studs welded or brazed to back of sign material or screwed into back of sign assembly unless otherwise indicated.
 - b. Through Fasteners: Exposed metal fasteners matching sign finish, with type of head indicated, and installed in predrilled holes.
- B. Adhesive: As recommended by sign manufacturer.
 - 1. [Verify adhesives have a VOC](#) content of 70 g/L or less.
 - 2. [Verify adhesive complies with the](#) testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Two-Face Tape: Manufacturer's standard high-bond, foam-core tape, 0.045 inch thick, with adhesive on both sides.

2.5 FABRICATION

- A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
 - 1. Mill joints to a tight, hairline fit. Form assemblies and joints exposed to weather to resist water penetration and retention.
 - 2. Conceal connections if possible; otherwise, locate connections where they are inconspicuous.
 - 3. Provide rabbets, lugs, and tabs necessary to assemble components and to attach to existing work. Drill and tap for required fasteners. Use concealed fasteners where possible; use exposed fasteners that match sign finish.
- B. Subsurface-Applied Graphics: Apply graphics to back face of clear face-sheet material to produce precisely formed image. Image shall be free of rough edges.
- C. Subsurface-Etched Graphics: Reverse etch back face of clear face-sheet material. Fill resulting copy with manufacturer's standard enamel. Apply opaque manufacturer's standard background color coating over enamel-filled copy.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.
1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.
 2. Install signs so they do not protrude or obstruct according to the accessibility standard.
 3. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.
- B. Mounting Methods:
1. Concealed Studs: Using a template, drill holes in substrate aligning with studs on back of sign. Remove loose debris from hole and substrate surface.
 - a. Masonry Substrates: Fill holes with adhesive. Leave recess space in hole for displaced adhesive. Place sign in position and push until flush to surface, embedding studs in holes. Temporarily support sign in position until adhesive fully sets.
 - b. Thin or Hollow Surfaces: Place sign in position and flush to surface, install washers and nuts on studs projecting through opposite side of surface, and tighten.
 2. Through Fasteners: Drill holes in substrate using predrilled holes in sign as template. Countersink holes in sign if required. Place sign in position and flush to surface. Install through fasteners and tighten.
 3. Adhesive: Clean bond-breaking materials from substrate surface and remove loose debris. Apply linear beads or spots of adhesive symmetrically to back of sign and of suitable quantity to support weight of sign after cure without slippage. Keep adhesive away from edges to prevent adhesive extrusion as sign is applied and to prevent visibility of cured adhesive at sign edges. Place sign in position, and push to engage adhesive. Temporarily support sign in position until adhesive fully sets.
 4. Two-Face Tape: Clean bond-breaking materials from substrate surface and remove loose debris. Apply tape strips symmetrically to back of sign and of suitable quantity to support weight of sign without slippage. Keep strips away from edges to prevent visibility at sign edges. Place sign in position, and push to engage tape adhesive.
 5. **Signs Mounted on Glass: Provide matching opaque plate on opposite side of glass to conceal mounting materials.**

END OF SECTION 10 14 25

SECTION 10 22 39 - FOLDING PANEL PARTITIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

- 1. Manually operated, acoustical panel partitions.

B. Related Requirements:

- 1. Division 05 Section "Structural Steel Framing" for overhead structural system supporting the folding panel partitions.

1.3 DEFINITIONS

- A. NIC: Noise Isolation Class.
- B. NRC: Noise Reduction Coefficient.
- C. STC: Sound Transmission Class.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. **Product Data:** For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- C. Shop Drawings: For operable panel partitions.
 - 1. Include plans, elevations, sections, attachment details.

2. Indicate stacking and operating clearances. Indicate location and installation requirements for hardware and track, blocking, and direction of travel.
- D. Samples for Initial Selection: For each type of exposed material, finish, covering, or facing.
 1. Include Samples of accessories involving color selection.
- E. Samples for Verification: For each type of exposed material, finish, covering, or facing, prepared on Samples of size indicated below:
 1. Textile Facing Material: Full width by not less than 36-inch-long section of fabric from dye lot to be used for the Work, with specified treatments applied. Show complete pattern repeat.
 2. Panel Edge Material: Not less than 3 inches long.
 3. Hardware: One of each exposed door-operating device.
- F. Delegated-Design Submittal: For operable panel partitions.
 1. Include design calculations for seismic restraints that brace tracks to structure above.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Partition track, track supports and bracing, switches, turning space, and storage layout.
 2. Suspended ceiling components.
 3. Structural members to which suspension systems will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. HVAC ductwork, outlets, and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Smoke detectors.
 - f. Access panels.
 6. Plenum acoustical barriers.
- B. Setting Drawings: For embedded items and cutouts required in other work, including support-beam, mounting-hole template.
- C. Qualification Data: For Installer and testing agency.
- D. Seismic Qualification Certificates: For operable panel partitions, tracks, accessories, and components, from manufacturer. Include seismic capacity of partition assemblies to remain in vertical position during a seismic event and the following:

1. Basis for Certification: Indicate whether certification is based on analysis, testing, or experience data, according to ASCE/SEI 7.
2. Detailed description of partition anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of operable panel partition.

1. Include approval letter signed by manufacturer acknowledging Owner-furnished panel facing material complies with requirements.

F. Product Test Reports: For each operable panel partition, for tests performed by a qualified testing agency.

G. Field quality-control reports.

H. Sample Warranty: For manufacturer's special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For operable panel partitions to include in maintenance manuals.

1. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - a. Panel finish facings and finishes for exposed trim and accessories. Include precautions for cleaning materials and methods that could be detrimental to finishes and performance.
 - b. Seals, hardware, track, track switches, carriers, and other operating components.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same production run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Panel Finish-Facing Material: Furnish full width in quantity to cover both sides of two panels when installed.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Protectively package and sequence panels in order for installation. Clearly mark packages and panels with numbering system used on Shop Drawings. Do not use permanent markings on panels.

1.11 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of operable panel partitions that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of operable panel partitions.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Division 01 Section "Quality Requirements," to design seismic bracing of tracks to structure above.
- B. Seismic Performance: Operable panel partitions shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the partition panels will remain in place without separation of any parts when subjected to the seismic forces specified."
- C. Acoustical Performance: Provide operable panel partitions tested by a qualified testing agency for the following acoustical properties according to test methods indicated:
 - 1. Sound-Transmission Requirements: Operable panel partition assembly tested for laboratory sound-transmission loss performance according to ASTM E90, determined by ASTM E413, and rated for not less than the STC indicated.
- D. Fire-Test-Response Characteristics: Provide panels with finishes complying with one of the following as determined by testing identical products by a testing and inspecting agency acceptable to authorities having jurisdiction:
 - 1. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 450 or less.
 - 2. Fire Growth Contribution: Complying with acceptance criteria of local code and authorities having jurisdiction when tested according to NFPA 265 Method B Protocol or NFPA 286.

2.2 OPERABLE ACOUSTICAL PANELS **OPP-1**

- A. Operable Acoustical Panels: Partition system, including panels, seals, finish facing, suspension system, operators, and accessories.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Modernfold, Inc; Acousti-Seal Encore or a comparable product by one of the following:
 - a. Hufcor, Inc.
 - b. KWIK-WALL Company.
- B. Panel Operation: Manually operated, paired panels.
- C. Panel Construction: As required to support panel from suspension components and with reinforcement for hardware attachment. Fabricate panels with tight hairline joints and concealed fasteners. Fabricate panels so finished in-place partition is rigid; level; plumb; aligned, with tight joints and uniform appearance; and free of bow, warp, twist, deformation, and surface and finish irregularities.
- D. Dimensions: Fabricate operable acoustical panel partitions to form an assembled system of dimensions indicated and verified by field measurements.
 - 1. Panel Width: Standard widths.
- E. STC: Not less than 56.
- F. Panel Weight: 12 lb/sq. ft. maximum.
- G. Panel Thickness: Nominal dimension of 4 1/4 inches.
 - 1. Steel Frame: Steel sheet, manufacturer's standard nominal minimum thickness for uncoated steel.
 - 2. Steel Face/Liner Sheets: Tension-leveled steel sheet, manufacturer's standard minimum nominal thickness for uncoated steel.
 - 3. Gypsum Board: ASTM C1396/C1396M.
- H. Panel Materials:
 - 1. **Recycled Content**: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
 - 2. **Adhesives**: Use adhesives that meet the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- I. Panel Closure: Manufacturer's standard unless otherwise indicated.
- J. Hardware: Manufacturer's standard as required to operate operable panel partition and accessories; with decorative, protective finish.
 - 1. Hinges: Manufacturer's standard.

- K. Finish Facing: Fabric wall covering.

2.3 SEALS

- A. Description: Seals that produce operable panel partitions complying with performance requirements and the following:
 - 1. Manufacturer's standard seals unless otherwise indicated.
 - 2. Seals made from materials and in profiles that minimize sound leakage.
 - 3. Seals fitting tight at contact surfaces and sealing continuously between adjacent panels and between operable panel partition perimeter and adjacent surfaces, when operable panel partition is extended and closed.
- B. Vertical Seals: Deep-nesting, interlocking astragals mounted on each edge of panel, with continuous, resilient acoustical seal.
- C. Horizontal Top Seals: Resilient, mechanical, retractable, constant-force-contact seal exerting uniform constant pressure on track when extended.
 - 1. Automatically Operated for Acoustical Panels: Extension and retraction of top seal automatically operated by movement of partition.
- D. Horizontal Bottom Seals: Resilient, mechanical, retractable, constant-force-contact seal exerting uniform constant pressure on floor when extended, ensuring horizontal and vertical sealing and resisting panel movement.
 - ~~1. Automatically Operated for Acoustical Panels: Extension and retraction of bottom seal automatically operated by movement of partition, with operating range not less than 2 inches between retracted seal and floor finish.~~
 - 1. **Mechanically Operated for Acoustical Panels: Extension and retraction of bottom seal by operating handle or built-in operating mechanism, with operating range not less than 2 inches between retracted seal and floor finish.**

2.4 PANEL FINISH FACINGS

- A. Description: Finish facings for panels that comply with indicated fire-test-response characteristics and that are factory applied to operable panel partitions with appropriate backing, using mildew-resistant nonstaining adhesive as recommended by facing manufacturer's written instructions.
 - 1. Apply facings free of air bubbles, wrinkles, blisters, and other defects, with edges tightly butted, and with invisible seams complying with Shop Drawings for location, and with no gaps or overlaps. Horizontal butted edges or seams are not permitted. Tightly secure and conceal raw and selvage edges of facing for finished appearance.
 - 2. Where facings with directional or repeating patterns or directional weave are indicated, mark facing top and attach facing in same direction.
 - 3. Match facing pattern 72 inches above finished floor.

- B. Fabric Wall Covering: Manufacturer's standard fabric, from same dye lot, treated to resist stains.
 - 1. Color/Pattern: As selected by Architect from manufacturer's full range.
 - 2. Surface Treatment: Stain resistant.
- C. Trimless Edges: Fabricate exposed panel edges so finish facing wraps uninterrupted around panel, covering edge and resulting in an installed partition with facing visible on vertical panel edges, without trim, for minimal sightlines at panel-to-panel joints.

2.5 SUSPENSION SYSTEMS

- A. Tracks: Manufacturer's standard #17 steel suspension system, with adjustable steel hanger rods for overhead support, designed for operation, size, and weight of operable panel partition indicated. Size track to support partition operation and storage without damage to suspension system, operable panel partitions, or adjacent construction. Limit track deflection to no more than 0.10 inch between bracket supports. Provide a continuous system of track sections and accessories to accommodate configuration and layout indicated for partition operation and storage.
 - 1. Panel Guide: Aluminum guide on both sides of the track to facilitate straightening of the panels; finished with factory-applied, decorative, protective finish.
 - 2. Head Closure Trim: As required for acoustical performance; with factory-applied, decorative, protective finish.
- B. Carriers: Trolley system as required for configuration type, size, and weight of partition and for easy operation; with ball-bearing wheels.
- C. Aluminum Finish: Mill finish or manufacturer's standard, factory-applied, decorative finish unless otherwise indicated.
- D. Steel Finish: Manufacturer's standard, factory-applied, corrosion-resistant, protective coating unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine flooring, floor levelness, structural support, and opening, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of operable panel partitions.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install operable panel partitions and accessories after other finishing operations, including painting, have been completed in area of partition installation.

- B. Install panels in numbered sequence indicated on Shop Drawings.
- C. Broken, cracked, chipped, deformed, or unmatched panels are not acceptable.
- D. Broken, cracked, deformed, or unmatched gasketing or gasketing with gaps at butted ends is not acceptable.
- E. Light-Leakage Test: Illuminate one side of partition installation and observe vertical joints and top and bottom seals for voids. Adjust partitions for alignment and full closure of vertical joints and full closure along top and bottom seals. Perform test and make adjustments before NIC testing.

3.3 FIELD QUALITY CONTROL

- A. NIC Testing: Engage a qualified testing agency to perform tests and inspections.
 - 1. Testing Methodology: Perform testing of installed operable panel partition for noise isolation according to ASTM E336, determined by ASTM E413, and rated for not less than NIC indicated. Adjust and fit partitions to comply with NIC test method requirements.
- B. An operable panel partition installation will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust operable panel partitions, hardware, and other moving parts to function smoothly, and lubricate as recommended by manufacturer.
- B. Verify that safety devices are properly functioning.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain operable panel partitions.

END OF SECTION 10 22 39

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to Specification Section 230800 Mechanical System Cx Requirements for Mechanical Systems Commissioning.

1.2 SUMMARY

- A. Section Includes:
 - 1. DDC system for monitoring and controlling of HVAC systems.
 - 2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.
- B. Related Documents:
 - 1. All work of this Division shall be coordinated and provided by the Building Management System (BMS) Contractor.
 - 2. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 15 Sections for details.
 - 3. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.
 - 4. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.
 - 5. **Dynamic Control Systems, Inc. is the current BMS Contractor. Please contact Edward Devine at edevine@dynamiccontrols.com.**
- C. **Related Sections Include the following:**
 - 1. **Division 01 Section "Sustainable Design Requirements – LEEDv4 ID+C."**

1.3 DEFINITIONS

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
 5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.
- D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
- E. Building Management System (BMS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BMS Contractor and to be interfaced to the associated work of other related trades.
- F. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.
- G. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
- H. COV: Changes of value.
- I. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- J. Distributed Control: Processing of system data is decentralized, and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.
- K. DOCSIS: Data-Over Cable Service Interface Specifications.
- L. E/P: Voltage to pneumatic.
- M. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- N. HLC: Heavy load conditions.

- O. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- P. I/P: Current to pneumatic.
- Q. LAN: Local area network.
- R. LNS: LonWorks Network Services.
- S. LON Specific Definitions:
 - 1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
 - 2. LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
 - 3. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
 - 4. LonWorks: Network technology developed by Echelon.
 - 5. Node: Device that communicates using CEA-709.1-C protocol and that is connected to a CEA-709.1-C network.
 - 6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
 - 7. Node ID: A unique 48-bit identifier assigned at factory to each CEA-709.1-C device. Sometimes called a "Neuron ID."
 - 8. Program ID: An identifier (number) stored in a device (usually EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
 - 9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark International for configuration properties.
 - 10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
 - 11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
 - 12. TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.
 - 13. TP/XF-1250: High-speed, 1.25-Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" typically used only to connect multiple TP/FT-10 networks.
 - 14. User-Defined Configuration Property Type (UCPT): Pronounced "U-Keep-It." A Configuration Property format type that is defined by device manufacturer.

15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.
- T. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- U. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
- V. Modbus TCP/IP: An open protocol for exchange of process data. Modbus protocol is another form of open protocol communications standard. Modbus consists of a messaging structure designed to establish master-slave, client-server communications between a wide range of intelligent devices. It supports traditional serial and Ethernet protocols. It is a truly open standard and is one of the most widely used protocols in the industrial manufacturing environment. There is no charge for using the protocol nor are there licensing fees.
- W. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- X. MTBF: Mean time between failures.
- Y. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
- Z. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- AA. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- BB. POT: Portable operator's terminal.
- CC. PUE: Performance usage effectiveness.
- DD. RAM: Random access memory.
- EE. RF: Radio frequency.
- FF. Router: Device connecting two or more networks at network layer.
- GG. Server: Computer used to maintain system configuration, historical and programming database.
- HH. TCP/IP: Transport control protocol/Internet protocol.
- II. UPS: Uninterruptible power supply.
- JJ. USB: Universal Serial Bus.

- KK. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
 - LL. VAV: Variable air volume.
 - MM. Niagara/Tridium prime building controller: This controller contains all of the central programming for the HVAC systems. Each prime building controller connects directly to the City's network. Larger buildings communicate through the prime building controller to multiple sub-controllers usually via BACnet protocol. Large building systems regularly push data to Web Supervisors for long term storage of data. Each system prime controller addresses a specific IP.
 - NN. Niagara/Tridium sub-controller: This controller interacts directly with the equipment, the prime building controller, and other sub-controllers via the BACnet.
 - OO. Niagara Web Supervisor: These are networked servers that act as:
 - 1. Long term storage of data for large buildings. They may also provide this for smaller buildings (or alternatively a virtual server can be used).
 - 2. A central push location for passwords and user configurations thus allowing one building operator to access multiple buildings with the same login and different responsibilities.
 - PP. Niagara 4 Workbench: This is a software program that allows both regular and power users to access systems, reprogram controllers, adjust usernames and passwords on the Niagara framework and do various other administrative uses.
 - QQ. Systems Integrator: Contracted vendor who will assist and oversee the integration of the controls and the control system specific protocols. Vendor will often liaise with the owner and the owner's Office of Innovation and Technology.
 - RR. WLED: White light emitting diode.
- 1.4 PREINSTALLATION MEETINGS
- A. Preinstallation Conference: Conduct conference at Project site or online.
- 1.5 ACTION SUBMITTALS
- A. Multiple Submissions:
 - 1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
 - 2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
 - 3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
 - a. Servers.
 - b. Routers.
 - c. Protocol analyzers.
 - d. DDC controllers.
 - e. Enclosures.
 - f. Electrical power devices.
 - g. UPS units.
 - h. Accessories.
 - i. Instruments.
 - j. Control dampers and actuators.
 - k. Control valves and actuators.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, and DDC controller.
2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.

9. Description of system database, including all data included in database, database capacity and limitations to expand database.
 10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
 11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- D. Sustainable Design Submittals:
1. Product Data: For adhesives, indicating VOC content.
 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
- E. Shop Drawings:
1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
 - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
 - c. Prepare Drawings using AutoCAD.
 2. Include plans, elevations, sections, and mounting details where applicable.
 3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 4. Detail means of vibration isolation and show attachments to rotating equipment.
 5. Plan Drawings indicating the following:
 - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
 - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
 - c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
 - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e. Network communication cable and raceway routing.
 - f. Information, drawn to scale.
 - g. Proposed routing of wiring, cabling, conduit, and tubing coordinated with building services for review before installation.
 6. Schematic drawings for each controlled HVAC system indicating the following:

- a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. A graphic showing location of control I/O in proper relationship to HVAC system.
 - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
- a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
8. DDC system network riser diagram indicating the following:
- a. Each device connected to network with unique identification for each.
 - b. Interconnection of each different network in DDC system.
 - c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
 - d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
9. DDC system electrical power riser diagram indicating the following:
- a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
 - c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - d. Power wiring type and size, race type, and size for each.
10. Monitoring and control signal diagrams indicating the following:
- a. Control signal cable and wiring between controllers and I/O.
 - b. Point-to-point schematic wiring diagrams for each product.

11. Color graphics indicating the following:
 - a. Itemized list of color graphic displays to be provided.
 - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
 - c. Intended operator access between related hierarchical display screens.

- F. During the design phase of a project, be sure to provide shop drawings to individuals experienced with the installation and startup of equipment related to this type of integration.
 1. Three copies of shop drawings of the entire BAS shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions.
 2. Complete system design information including:
 - a. Data entry forms for initial parameters.
 - b. Valve, and damper schedules showing:
 - 1) Size
 - 2) Configuration
 - 3) Capacity
 - 4) Location
 - c. Wiring and piping interconnection diagrams, including panel and device power and sources.
 - d. Equipment lists (bill of materials) of all proposed devices and equipment.
 - e. Software design data including:
 - 1) Flow chart of each DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
 - 2) Sequence of operation relating to all flow chart functions
 - f. Control sequences for each major building-level system
 - g. DDC installation, block diagrams, and wiring diagrams for each piece of equipment
 - h. DDC panel physical layout and schematics
 - i. The BAS contractor shall submit an architecture layout that depicts devices from the JACE to NAC down to the device level

- G. Sequence of Operations:
 1. A complete written Sequence of Operation shall also be included with the submittal package. The BAS Contractor shall coordinate data from other contractors supplying products and systems, as part of their package and shall provide catalog data sheets, wiring diagrams and point lists to the owner for proper coordination of work.

- H. Product Data:
 1. Complete list of product data including:
 - a. Data sheets of all products
 - b. Valve, damper, and well and tap schedules showing size, configuration, capacity, and location of all equipment

- I. Project Information:
 1. Certification of installer qualifications

- J. System Graphic Displays:

1. The BAS Contractor shall include web browser graphical displays through which an operator can perform real-time access and control functions. The graphical displays shall consist of all major building-level systems (air handler units, VAV boxes, chillers, boilers etc.) graphic displays, alarm displays, scheduling displays, and trending displays.
 2. BAS Contractors shall utilize the City of Philadelphia graphic templates when available. In absence of a City graphic template, owner shall provide an example of an acceptable graphic template.
 3. Submittal shall include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are to be 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and owner. Submittal shall also include a copy of the expected main dashboard viewlets being provided for owner configuration. Viewlets should include:
 - a. Global Scheduling for Site
 - b. Alarms
 - c. Trending and Reports
- K. OIT Coordination Sheet
1. BAS contractor shall coordinate the completion of the OIT Data Sheet (Appendix A) at the start of and throughout the delivery of the project.
- L. Upon completion of the work, provide a complete set of 'as-built' drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files.
- M. Contract Closeout Information:
1. Operating and maintenance manuals including recommended set points and schedules and holiday scheduling instructions.
 2. Owner instruction report.
 3. Certification that Owner Training has been provided by RBOP installer.
 4. As Built Instrumentation and Control Diagrams.
 5. Plan As Builts at 1/8 inch scale showing:
 - a. Upon completion of the work, provide a complete set of 'as-built' drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files.
 - b. Eight copies of the 'as-built' drawings shall be provided in addition to the documents on compact disk.
 - c. Division 23, 25 and 26 contractors shall provide as-builts for their portions of work.
 - d. The RBOP Contractor shall be responsible for as-builts pertaining to overall RBOP architecture and network diagrams. All as built drawings shall also be installed into the RBOP server in a dedicated directory.
 - e. Communication cable circuiting drawing with DDC panels and communication devices labeled.
 - f. Power wiring circuiting drawing showing 120-volt circuit source and low voltage transformer locations, identifications, and circuit roués to each controlled device per transformer for the DDC system.
- N. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
 2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
 3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outpoints.
 - d. Operator workstation failure.
 - e. Server failure.
 - f. Gateway failure.
 - g. Network failure
 - h. Controller failure.
 - i. Instrument failure.
 - j. Control damper and valve actuator failure.
 4. Complete bibliography of documentation and media to be delivered to Owner.
 5. Description of testing plans and procedures.
 6. Description of Owner training.
- O. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.
1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
 2. Schedule and design calculations for control dampers and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Face velocity at Project design and minimum airflow conditions.
 - c. Pressure drop across damper at Project design and minimum airflow conditions.
 - d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - e. Maximum close-off pressure.
 - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
 3. Schedule and design calculations for control valves and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Pressure-differential drop across valve at Project design flow condition.
 - c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.

- d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
4. Schedule and design calculations for selecting flow instruments.
- a. Instrument flow range.
 - b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
 - c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
 - d. Pressure-differential loss across instrument at Project design flow conditions.
 - e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Product installation location shown in relationship to room, duct, pipe and equipment.
 - b. Structural members to which products will be attached.
 - c. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices and other installed devices.
 - d. Size and location of wall access panels for products installed behind walls and requiring access.
2. Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Ceiling components.
 - b. Size and location of access panels for products installed above inaccessible ceiling assemblies and requiring access.
 - c. Items penetrating finished ceiling including the following:
 - 1) Lighting fixtures.
 - 2) Air outlets and inlets.
 - 3) Speakers.
 - 4) Sprinklers.
 - 5) Access panels.

- 6) Motion sensors.
- 7) Pressure sensors.
- 8) Temperature sensors and other DDC control system instruments.

B. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
2. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.

C. Product Test Reports: For each product that requires testing to be performed by manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

- i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
- j. List of recommended spare parts with part numbers and suppliers.
- k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list shall be indicated for each year.
- C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during two-year period following warranty period.

1.9 QUALITY ASSURANCE

- A. DDC System Provider Qualifications:
 - 1. Authorized representative of, and trained by, DDC system manufacturer.
 - 2. In-place facility located within 25 miles of Project.
 - 3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
 - 4. Demonstrated past experience on five projects of similar complexity, scope and value.
 - 5. Each person assigned to Project shall have demonstrated past experience.
 - 6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 - 7. Service and maintenance staff assigned to support Project during warranty period.
 - 8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
 - 9. DDC system manufacturer's backing to take over execution of Work if necessary, to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.
- B. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
4. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary, to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.
3. Warranty service shall occur during normal business hours and commence within 16 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 WEB ACCESS

A. DDC system shall be Web based or Web compatible.

1. Web-Based Access to DDC System:
 - a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed

- using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
- b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
 - c. Web access shall be password protected.
2. Web-Compatible Access to DDC System:
- a. Workstation and server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
 - b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
 - c. Web access shall be password protected.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.
1. System Performance Objectives:
 - a. DDC system shall manage HVAC systems.
 - b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
 - c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
 - d. DDC system shall operate while unattended by an operator and through operator interaction.
 - e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.
- B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
 2. Smoke-Developed Index: 50 or less.
- C. DDC System Speed:
1. Response Time of Connected I/O:
 - a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.

- b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
 - c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
 - d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
2. Display of Connected I/O:
- a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
 - b. Binary point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
 - c. Alarms of analog and digital points connected to DDC system shall be displayed within 30 seconds of activation or change of state.
 - d. Graphic display refresh shall update within eight seconds.
 - e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.
- D. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.
- E. DDC System Data Storage:
1. Include server(s) with disk drive data storage to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
 2. When logged onto a server, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
 3. Server(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
 4. Server(s) shall use IT industry-standard database platforms such as Microsoft SQL Server and Microsoft Data Engine (MSDE).
- F. Future Expandability:
1. DDC system size shall be expandable to an ultimate capacity of at least two times total I/O points indicated.
 2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.

3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.
- G. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
1. Energy:
 - a. Electric Power: Within 1 percent of reading.
 - b. Requirements indicated on Drawings for meters not supplied by utility.
 2. Flow:
 - a. Air: Within 5 percent of design flow rate.
 - b. Air (Terminal Units): Within 5 percent of design flow rate.
 3. Gas:
 - a. Carbon Dioxide: Within 50 ppm.
 - b. Carbon Monoxide: Within 5 ppm
 - c. Hydrogen: with 20 ppm
 - d. NOx: Within 5 ppm
 4. Moisture (Relative Humidity):
 - a. Air: Within 5 percent RH.
 - b. Space: Within 5 percent RH.
 - c. Outdoor: Within 5 percent RH.
 5. Pressure:
 - a. Air, Ducts and Equipment: 1 percent of instrument range.
 6. Speed: Within 5 percent of reading.
 7. Temperature, Dew Point:
 - a. Air: Within 1 deg F (0.5 deg C).
 - b. Space: Within 1 deg F (0.5 deg C).
 - c. Outdoor: Within 2 deg F (1 deg C).
 8. Temperature, Dry Bulb:
 - a. Air: Within 1 deg F (0.5 deg C).
 - b. Space: Within 1 deg F (0.5 deg C).
 - c. Outdoor: Within 2 deg F (1 deg C).
 - d. Temperature Difference: Within 0.25 deg F (0.15 deg C).
 - e. Other Temperatures Not Indicated: Within 1 deg F (0.5 deg C).
 9. Temperature, Wet Bulb:

- a. Air: Within 0.5 deg F (0.2 deg C).
 - b. Space: Within 0.5 deg F (0.2 deg C)
 - c. Outdoor: Within 1 deg F (0.5 deg C).
- H. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:
- 1. Current:
 - a. Milliamperes: Nearest 1/100th of a milliampere.
 - b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
 - 2. Energy:
 - a. Electric Power:
 - 1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
 - 2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
 - 3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
 - b. Thermal, Rate:
 - 1) Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh (For watts, nearest watt up to 1000 W; for kilowatts, round to nearest kilowatt up to 1000 kW; nearest 10 kW between 1000 and 10,000 kW; nearest 100 kW for above 10,000 kW).
 - 2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons (For watts, nearest watt up to 1000 W; for kilowatts, round to nearest kilowatt up to 1000 kW; nearest 10 kW between 1000 and 10,000 kW; nearest 100 kW for above 10,000 kW).
 - c. Thermal, Usage:
 - 1) Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu (For watt-hours, nearest watt-hour up to 1000 Wh; for kilowatt-hours, round to nearest kilowatt-hour up to 1000 kWh; nearest 10 kWh between 1000 and 10,000 kWh; nearest 100 kWh for above 10,000 kWh).
 - 2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above

10,000 tons (For watt-hours, nearest watt-hour up to 1000 Wh; for kilowatt-hours, round to nearest kilowatt-hour up to 1000 kWh; nearest 10 kWh between 1000 and 10,000 kWh; nearest 100 kWh for above 10,000 kWh).

3. Flow:
 - a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm (Nearest 1/10th of a L/s through 100 L/s; nearest L/s between 100 and 1000 L/s; nearest 10 L/s between 1000 and 10,000 L/s; nearest 100 L/s above 10,000 L/s).
 4. Gas:
 - a. Carbon Dioxide: Within 50 ppm.
 - b. Carbon Monoxide: Within 5 ppm
 - c. Hydrogen: with 20 ppm
 - d. NOx: Within 5 ppm
 5. Moisture (Relative Humidity):
 - a. Relative Humidity (Percentage): Nearest 1 percent.
 6. Speed:
 - a. Rotation (rpm): Nearest 1 rpm.
 - b. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm (Nearest 1/100th of a M/s through 10 M/s; nearest 1/10th of a M/s above 10 M/s).
 7. Position, Dampers (Percentage Open): Nearest 1 percent.
 8. Pressure:
 - a. Air, Ducts and Equipment: Nearest 1/10th in. w.c. (Nearest Pa up to 1000 Pa; nearest 10 Pa above 1000 Pa).
 9. Temperature:
 - a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
 - b. Outdoor: Nearest degree.
 - c. Space: Nearest 1/10th of a degree.
 10. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.
- I. Control Stability: Control variables indicated within the following limits:
1. Flow:
 - a. Air, Ducts and Equipment, except Terminal Units: Within 2 percent of design flow rate.

2. Gas:
 - a. Carbon Dioxide: Within 50 ppm.
 - b. Carbon Monoxide: Within 5 ppm
 - c. Hydrogen: with 20 ppm
 - d. NOx: Within 5 ppm
 3. Moisture (Relative Humidity):
 - a. Air: Within 2 percent RH.
 - b. Space: Within 5 percent RH.
 - c. Outdoor: Within 5 percent RH.
 4. Pressure:
 - a. Air, Ducts and Equipment: 1 percent of instrument range.
 5. Temperature, Dew Point:
 - a. Air: Within 1 deg F (0.5 deg C).
 6. Temperature, Dry Bulb:
 - a. Air: Within 2 deg F (1 deg C).
 - b. Space: Within 2 deg F (1 deg C).
 7. Temperature, Wet Bulb:
 - a. Air: Within 1 deg F (0.5 deg C).
- J. Environmental Conditions for Controllers and Routers:
1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.
 2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 2.
 - b. Outdoors, Unprotected: Type 4.
 - c. Indoors, Heated with Filtered Ventilation: Type 1.
 - d. Indoors, Heated with Non-Filtered Ventilation: Type 2.

- e. Indoors, Heated and Air Conditioned: Type 1.
- f. Mechanical Equipment Rooms:
 - 1) Air-Moving Equipment Rooms: Type 1.
- g. Localized Areas Exposed to Washdown: Type 4.
- h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
- i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

K. Environmental Conditions for Instruments and Actuators:

- 1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.
- 2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 2.
 - b. Outdoors, Unprotected: Type 4.
 - c. Indoors, Heated with Filtered Ventilation: Type 1.
 - d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
 - e. Indoors, Heated and Air Conditioned: Type 1.
 - f. Mechanical Equipment Rooms:
 - 1) Boiler Rooms: Type 4.
 - 2) Air-Moving Equipment Rooms: Type 1.
 - g. Localized Areas Exposed to Washdown: Type 4.
 - h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

L. DDC System Reliability:

- 1. Design, install and configure DDC controllers and routers to yield a MTBF of at least 40,000 hours, based on a confidence level of at least 90 percent. MTBF value shall include any failure for any reason to any part of products indicated.

2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control.
3. Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

M. Electric Power Quality:

1. Power-Line Surges:

- a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
- b. Do not use fuses for surge protection.
- c. Test protection in the normal mode and in the common mode, using the following two waveforms:
 - 1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
 - 2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

- a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
 - 1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
 - 2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
 - 3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
 - 4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

N. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

O. UPS:

1. DDC system products powered by UPS units shall include the following:
 - a. Servers.
 - b. DDC controllers, except application-specific controllers.

- P. Continuity of Operation after Electric Power Interruption:
 - 1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.4 SYSTEM ARCHITECTURE

- A. System architecture shall consist of no more than two or three levels of LANs.
 - 1. Level one LAN shall connect network controllers and operator workstations.
 - 2. Level one or Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
 - 3. Level two or Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.
 - 4. Level two or Level three LAN shall connect application-specific controllers to application-specific controllers.
- B. Minimum Data Transfer and Communication Speed:
 - 1. LAN Connecting Network Controllers: 100 Mbps.
 - 2. LAN Connecting Programmable Application Controllers: 100 kbps.
 - 3. LAN Connecting Application-Specific Controllers: 19,200 bps.
- C. DDC system shall consist of dedicated LANs that are not shared with other building systems and tenant data and communication networks.
- D. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.
- E. System architecture shall perform modifications without having to remove and replace existing network equipment.
- F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.
- G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.
- H. Special Network Architecture Requirements:
 - 1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is

controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.5 DDC SYSTEM OPERATOR INTERFACES

- A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
 - 1. Portable operator terminal with hardwired connection through LAN port.
 - 2. PDA with wireless connection through LAN router.
 - 3. Remote connection using outside of system personal computer or PDA through Web access.
- B. Access to system, regardless of operator means used, shall be transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable operator workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:
 - 1. Each mechanical equipment room.
- D. POT:
 - 1. Connect DDC controller through a communications port local to controller.
 - 2. Able to communicate with any DDC system controller that is directly connected or connected to DDC system.
- E. Personal Digital Assistant:
 - 1. Connect to system through a wireless router connected to LAN.
 - 2. Able to communicate with any DDC controller connected to DDC system.
- F. Critical Alarm Reporting:
 - 1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
 - 2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
 - 3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.
- G. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.6 NETWORKS

- A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. EIA-485A.
4. IP.
5. IEEE 8802-3, Ethernet.

2.7 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. Industry Standard Protocols:

1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
 - a. ASHRAE 135.
 - b. Modbus Application Protocol Specification V1.1b.

2. Operator workstations and network controllers shall communicate through ASHRAE 135 protocol.
3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
4. Portions of DDC system networks using CEA-709.1-C communication protocol shall be an open implementation of LonWorks technology using CEA-709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.
5. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.
6. Gateways shall be used to connect networks and network devices using different protocols.

2.8 PORTABLE OPERATOR TERMINAL

- A. Description: Handheld device with integral keypad or touch screen operator interface.
- B. Display: Multiple lines of text display for use in operator interaction with DDC system.
- C. Cable: Flexible cable, at least 36 inches long, with a plug-in jack for connection to DDC controllers, network ports or instruments with an integral LAN port. As an alternative to hardwired connection, POT shall be accessible to DDC controllers through a wireless network connection.
- D. POT shall be powered through network connection.
- E. Connection of POT to DDC system shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.
- F. POT shall give operator the ability to do the following:
 1. Display and monitor BI point status.
 2. Change BO point set point (on or off, open or closed).
 3. Display and monitor analog point values.
 4. Change analog control set points.
 5. Command a setting of AO point.
 6. Display and monitor I/O point in alarm.
 7. Add a new or delete an existing I/O point.
 8. Enable and disable I/O points, initiators, and programs.
 9. Display and change time and date.
 10. Display and change time schedules.
 11. Display and change run-time counters and run-time limits.
 12. Display and change time and event initiation.
 13. Display and change control application and DDC parameters.
 14. Display and change programmable offset values.

15. Access DDC controller initialization routines and diagnostics.

2.9 SERVERS

A. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.
3. Redundant Array of Independent Disks: one configuration.
4. Drive Bays: Eight at 2.5 inches (65 mm) or eight at 3.5 inches (90 mm).
5. Hard-Drive Storage: two drives.
6. Network Interface: Dual port Ethernet.
7. DVD +RW Drive.
8. Color, flat-screen display.
9. Keyboard and mouse.
10. Next-day on-site warranty for three-year period following Substantial Completion.

B. Servers shall include the following:

1. Full-feature backup server (server and backup minimum requirement).
2. Software licenses.
3. CAT-5e or CAT-6 cable installation between server(s) and network.

C. Web Server:

1. If required to be separate, include Web server hardware and software to match, except backup server is not required.
2. Firewalls between server Web and networks.
3. Password protection for access to server from Web server.
4. CAT-5e or CAT 6 cable installation between the server(s) and building Ethernet network.

D. Power each server through a dedicated UPS unit.

- 1.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 32-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.

4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language pronouncing and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
 - a. Operator access to DDC system shall be under password control.
 - b. An alphanumeric password shall be field assignable to each operator.
 - c. Operators shall be able to access DDC system by entry of proper password.
 - d. Operator password shall be same regardless of which computer or other interface means is used.
 - e. Additions or changes made to passwords shall be updated automatically.
 - f. Each operator shall be assigned an access level to restrict access to data and functions the operator is capable of performing.
 - g. Software shall have at least five access levels.
 - h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
 - i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.
7. Data Segregation:
 - a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
 - b. Include at least 32 segregation groups.
 - c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
 - d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.

- e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
 - f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.
8. Operators shall be able to perform commands including, but not limited to, the following:
- a. Start or stop selected equipment.
 - b. Adjust set points.
 - c. Add, modify, and delete time programming.
 - d. Enable and disable process execution.
 - e. Lock and unlock alarm reporting for each point.
 - f. Enable and disable totalization for each point.
 - g. Enable and disable trending for each point.
 - h. Override control loop set points.
 - i. Enter temporary override schedules.
 - j. Define holiday schedules.
 - k. Change time and date.
 - l. Enter and modify analog alarm limits.
 - m. Enter and modify analog warning limits.
 - n. View limits.
 - o. Enable and disable demand limiting.
 - p. Enable and disable duty cycle.
 - q. Display logic programming for each control sequence.
9. Reporting:
- a. Generated automatically and manually.
 - b. Sent to displays, printers and disk files.
 - c. Types of Reporting:
 - 1) General listing of points.
 - 2) List points currently in alarm.
 - 3) List of off-line points.
 - 4) List points currently in override status.
 - 5) List of disabled points.
 - 6) List points currently locked out.
 - 7) List of items defined in a "Follow-Up" file.
 - 8) List weekly schedules.
 - 9) List holiday programming.
 - 10) List of limits and deadbands.
10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

- 1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable

- (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
 3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
 4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
 5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
 6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
 7. Graphics are to be online programmable and under password control.
 8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
 9. Graphics shall also contain software points.
 10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
 11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
 12. Display operator accessed data on the monitor.
 13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
 14. Include operator with means to directly access graphics without going through penetration path.
 15. Dynamic data shall be assignable to graphics.
 16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
 17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
 18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
 19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
 - a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
 - c. Keyboard equivalent shall be available for those operators with that preference.
 20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature

shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.

21. Help Features:
 - a. On-line context-sensitive help utility to facilitate operator training and understanding.
 - b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
 - 1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.
 - c. Available for Every Menu Item:
 - 1) Index items for each system menu item.
 22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
 - a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols.
 - b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
 - 1) Define background screens.
 - 2) Define connecting lines and curves.
 - 3) Locate, orient and size descriptive text.
 - 4) Define and display colors for all elements.
 - 5) Establish correlation between symbols or text and associated system points or other displays.
- D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
 2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
 - a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
 3. Control schematic for each of following, including a graphic system schematic representation with point identification, set point and dynamic value indication.
 4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.

5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, and other network devices.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. As a minimum, include the following modification capability:
 - a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
 - b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
 - c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.
 - d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
 - e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
 - f. Point related change capability shall include the following:
 - 1) System and point enable and disable.
 - 2) Run-time enable and disable.
 - 3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
 - 4) Assignment of alarm and warning limits.
 - g. Application program change capability shall include the following:
 - 1) Enable and disable of software programs.
 - 2) Programming changes.
 - 3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.
4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:
 - a. Proportional control (P).
 - b. Proportional plus integral (PI).
 - c. Proportional plus integral plus derivative (PID).
 - d. Adaptive and intelligent self-learning control.
 - 1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
 - 2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.
7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:
 - a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
 - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
 - c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
 - d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.

a. Class 1:

- 1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
- 2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
- 3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

b. Class 2:

- 1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
- 2) Acknowledgement may be through a multiple alarm acknowledgment.

c. Class 3:

- 1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
- 2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
- 3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
- 4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

d. Class 4:

- 1) Routine maintenance or other types of warning alarms.
- 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.

3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
 4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
 5. Reports and logs shall be stored on server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
 6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.
- H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.
1. All I/O: With current status and values.
 2. Alarm: All current alarms, except those in alarm lockout.
 3. Disabled I/O: All I/O points that are disabled.
 4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
 5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
 6. Logs:
 - a. Alarm history.
 - b. System messages.
 - c. System events.
 - d. Trends.
- I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.
- J. Tenant Override Reports: Prepare Project-specific reports.
1. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.
 2. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
 3. Annual summary report that shows after-hours HVAC usage on a monthly basis.
- K. Utility Reports: Prepare Project-specific reports.
1. Electric Report:
 - a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - c. Include annual report showing the monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
 - d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as lighting, receptacles and HVAC equipment showing daily electrical consumption and peak electrical demand.

- e. For each weekly, monthly and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.
2. Natural Gas Report:
 - a. Include weekly report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
 - b. Include monthly report showing the daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
 - c. Include annual report showing the monthly natural gas consumption and peak natural gas demand with time and date stamp for each meter.
 - d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
 - e. For each weekly, monthly and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.
 3. Service Water Report:
 - a. Include weekly report showing daily service water consumption and peak service water demand with time and date stamp for each meter.
 - b. Include monthly report showing the daily service water consumption and peak service water demand with time and date stamp for each meter.
 - c. Include annual report showing the monthly service water consumption and peak service water demand with time and date stamp for each meter.
 - d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as cooling tower makeup and irrigation showing daily service water consumption and peak service water demand.
 - e. For each weekly, monthly and annual report, include sum total of all submeters in building showing service water consumption and peak service water demand.
- L. Energy Reports: Prepare Project-specific daily, weekly, monthly annual and since-installed energy reports.
1. Prepare report for each purchased energy utility, indicating the following:
 - a. Time period being reported with beginning and end date, and time indicated.
 - b. Consumption in units of measure commonly used to report specific utility consumption over time.
 - c. Gross area served by utility.
 - d. Consumption per unit area served using utility-specific unit of measure.
 - e. Cost per utility unit.
 - f. Utility cost per unit area.
 - g. Convert all utilities to a common energy consumption unit of measure and report for each utility.
 - h. Consumption per unit area using common unit of measure.
 2. Prepare report for each renewable energy source, indicating the following:
 - a. Time period being reported with beginning and end date, and time indicated.

- b. Harvested energy in units of measure commonly used to report specific harvested energy consumption over time.
 - c. Gross area served by renewable energy source.
 - d. Harvested energy per unit area served using specific unit of measure.
 - e. Cost per purchased utility unit displaced by renewable energy.
 - f. Cost savings attributed to harvested energy source.
 - g. Cost savings per unit area attributed to harvested energy.
 - h. Convert all renewable energy sources to a common energy consumption unit of measure and report for each.
 - i. Harvested energy per unit area using common unit of measure.
 3. Prepare purchased energy utility report for each submetered area that indicates the following:
 - a. Time period being reported with beginning and end date, and time indicated.
 - b. Gross area served.
 - c. Energy consumption by energy utility type.
 - d. Energy consumption per unit area by energy utility type.
 - e. Total energy consumption of all utilities in common units of measure.
 - f. Total energy consumption of all utilities in common units of measure per unit area.
 - g. Unit energy cost by energy utility type.
 - h. Energy cost by energy utility type.
 - i. Energy cost per unit area by energy utility type.
 - j. Total cost of all energy utilities.
 - k. Total cost of all energy utilities per unit area.
 4. Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report shall indicate the following:
 - a. Time period being reported with beginning and end date, and time indicated.
 - b. Gross area served.
 - c. Energy consumption by energy utility type.
 - d. Energy consumption per unit area by energy utility type.
 - e. Total energy consumption of all utilities in common units of measure.
 - f. Total energy consumption of all utilities in common units of measure per unit area.
 - g. Unit energy cost by energy utility type.
 - h. Energy cost by energy utility type.
 - i. Energy cost per unit area by energy utility type.
 - j. Total cost of all energy utilities.
 - k. Total cost of all energy utilities per unit area.
- M. Weather Reports:
1. Include daily report showing the following:
 - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).

- e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
 - f. Daily minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
2. Include weekly report showing the following:
- a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).
 - e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
 - f. Weekly minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
3. Include monthly report showing the following:
- a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).
 - e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
 - f. Monthly minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
4. Include annual (12-month) report showing the following:
- a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Monthly minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Monthly minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F (13 deg C).
 - e. Number of cooling degree-days for each day calculated from a base temperature of 65 deg F (18 deg C).
 - f. Annual minimum, maximum, and average outdoor carbon dioxide level.
 - g. Monthly minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.

N. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
 2. Trends shall be associated into groups, and a trend report shall be set up for each group.
 3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
 4. Preset trend intervals for each I/O point after review with Owner.
 5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
 6. When drive storage memory is full, most recent data shall overwrite oldest data.
 7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.
- O. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.
1. Each trend shall include interval, start time, and stop time.
 2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server hard drives.
 3. Data shall be retrievable for use in spreadsheets and standard database programs.
- P. Programming Software:
1. Include programming software to execute sequences of operation indicated.
 2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
 3. Programming software shall be any of the following:
 - a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
 - 1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
 - 2) Programming tools shall be viewable in real time to show present values and logical results of each function block.
 - b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
 - c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.
 4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.
- Q. Database Management Software:

1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
 - a. Backup.
 - b. Purge.
 - c. Restore.
4. Database management software shall support the following:
 - a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
 - b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
 - c. Backup: Include means to create a database backup file and select a storage location.
 - d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.
5. Database management software shall include information of current database activity, including the following:
 - a. Ready.
 - b. Purging record from a database.
 - c. Action failed.
 - d. Refreshing statistics.
 - e. Restoring database.
 - f. Shrinking a database.
 - g. Backing up a database.
 - h. Resetting Internet information services.
 - i. Starting network device manager.
 - j. Shutting down the network device manager.
 - k. Action successful.
6. Database management software monitoring functions shall continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window shall have the following sections:
 - a. Allow operator to set and review scan intervals and start times.
 - b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.

- c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
 - d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
 - e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.
9. Monitoring settings taskbar shall include the following informational icons:
- a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
 - b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
 - c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

2.11 ASHRAE 135 GATEWAYS

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled equipment includes, but is not limited to, VRF System and DOAS Unit.
- B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
 - 1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
 - 2. Write to all writable object properties on non-BACnet network from BACnet network and vice versa where applicable.
 - 3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
 - 4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
 - 5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
 - 6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.12 ASHRAE 135 PROTOCOL ANALYZER

- A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.
- B. Analyzer shall include the following minimum capabilities:
 - 1. Capture and store to a file data traffic on all network levels.
 - 2. Measure bandwidth usage.
 - 3. Filtering options with ability to ignore select traffic.

2.13 WIRELESS ROUTERS FOR OPERATOR INTERFACE

- A. Single-Band Wireless Routers:
 - 1. Description: High-speed router with integral Ethernet ports.
 - 2. Technology: IEEE 802.11n; 2.4-GHz speed band.
 - 3. Speed: Up to 300 Mbps.
 - 4. Compatibility: IEEE 802.11n/g/b/a wireless devices.
 - 5. Ethernet Ports: Four, gigabit (1000 Mbps).
 - 6. Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 according to IEEE 802.11i.
- B. Dual-Band Wireless Routers:
 - 1. Description: High-speed, dual-band router with integral Ethernet ports and USB port.
 - 2. Technology: IEEE 802.11n; 2.4- and 5-GHz speed bands.
 - 3. Speed: Up to 300 Mbps on 2.4-GHz band and up to 450 Mbps on 5-GHz band.
 - 4. Compatibility: IEEE 802.11n/g/b/a wireless devices.
 - 5. Ethernet Ports: Four, gigabit (1000 Mbps).
 - 6. USB Port: One, USB 2.0 or 3.0.
 - 7. Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 according to IEEE 802.11i.

2.14 DDC CONTROLLERS

- A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.
- C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.
- E. Environment Requirements:
 - 1. Controller hardware shall be suitable for the anticipated ambient conditions.

2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F (Zero to 50 deg C).
 3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F (40 to 65 deg C).
- F. Power and Noise Immunity:
1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
 2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches (900 mm) of enclosure.
- G. DDC Controller Spare Processing Capacity:
1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
 - a. Network Controllers: 50 percent.
 - b. Programmable Application Controllers: Not less than 60 percent.
 - c. Application-Specific Controllers: Not less than 70 percent.
 2. Memory shall support DDC controller's operating system and database and shall include the following:
 - a. Monitoring and control.
 - b. Energy management, operation and optimization applications.
 - c. Alarm management.
 - d. Historical trend data of all connected I/O points.
 - e. Maintenance applications.
 - f. Operator interfaces.
 - g. Monitoring of manual overrides.
- H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
1. Network Controllers:
 - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: Two.
 - 2) AOs: Two.
 - 3) BIs: Three.
 - 4) BOs: Three.
 2. Programmable Application Controllers:
 - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
 - a. Minimum Spare I/O Points per Controller:

- 1) AIs: Two.
 - 2) AOs: Two.
 - 3) BIs: Three.
 - 4) BOs: Three.
3. Application-Specific Controllers:
- b. 10 percent of each AI, AO, BI, and BO point connected to controller.
 - a. Minimum Spare I/O Points per Controller:
 - 1) AIs: Two.
 - 2) AOs: Two.
 - 3) BIs: Three.
 - 4) BOs: Three.
- I. Maintenance and Support: Include the following features to facilitate maintenance and support:
1. Mount microprocessor components on circuit cards for ease of removal and replacement.
 2. Means to quickly and easily disconnect controller from network.
 3. Means to quickly and easily access connect to field test equipment.
 4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.
- J. Input and Output Point Interface:
1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
 2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
 3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
 4. AIs:
 - a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
 - b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
 - c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
 - d. Signal conditioning including transient rejection shall be provided for each AI.
 - e. Capable of being individually calibrated for zero and span.
 - f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
 5. AOs:

- a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
 - b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
 - c. Capable of being individually calibrated for zero and span.
 - d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.
6. BIs:
- a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
 - b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
 - c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
 - d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
 - e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.
7. BOs:
- a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.
 - 1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
 - 2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.
 - b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
 - c. BOs shall be selectable for either normally open or normally closed operation.
 - d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.

2.15 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.

3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or PDA.
2. Local Keypad and Display:
 - a. Equip controller with local keypad and digital display for interrogating and editing data.
 - b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.16 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or PDA>
2. Local Keypad and Display:
 - a. Equip controller with local keypad and digital display for interrogating and editing data.
 - b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.17 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.18 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and usernames.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

- a. Include separate schedules for each day of week.
- b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
- c. Each schedule may consist of up to 10 events.
- d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

- a. Include ability for operator to designate any day of the year as an exception schedule.
- b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:
 - a. Include capability for operator to define up to 99 special or holiday schedules.
 - b. Schedules may be placed on scheduling calendar and will be repeated each year.
 - c. Operator shall be able to define length of each holiday period.

- D. System Coordination:
 1. Include standard application for proper coordination of equipment.
 2. Application shall include operator with a method of grouping together equipment based on function and location.
 3. Group may then be used for scheduling and other applications.

- E. Binary Alarms:
 1. Each binary point shall be set to alarm based on operator-specified state.
 2. Include capability to automatically and manually disable alarming.

- F. Analog Alarms:
 1. Each analog object shall have both high and low alarm limits.
 2. Alarming shall be able to be automatically and manually disabled.

- G. Alarm Reporting:
 1. Operator shall be able to determine action to be taken in event of an alarm.
 2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
 3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

- H. Remote Communication:
 1. System shall have ability to dial out in the event of an alarm.

- I. Electric Power Demand Limiting:
 1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
 2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
 3. Demand reduction shall be accomplished by the following means:
 - a. Reset air-handling unit supply temperature set points.
 - b. Reset space temperature set points.
 - c. De-energize equipment based on priority.

4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:
 - a. Addition and deletion of loads controlled.
 - b. Changes in demand intervals.
 - c. Changes in demand limit for meter(s).
 - d. Maximum shutoff time for equipment.
 - e. Minimum shutoff time for equipment.
 - f. Select rotational or sequential shedding and restoring.
 - g. Shed and restore priority.
7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:
 - a. Total electric consumption.
 - b. Peak demand.
 - c. Date and time of peak demand.
 - d. Daily peak demand.
- J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
- K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
- L. Control Loops:
 1. Support any of the following control loops, as applicable to control required:
 - a. Two-position (on/off, open/close, slow/fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control.
 - 1) Include PID algorithms with direct or reverse action and anti-windup.
 - 2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Controlled variable, set point, and PID gains shall be operator-selectable.
 - e. Adaptive (automatic tuning).
- M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.
- N. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.19 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Individual wall-mounted single-door enclosures shall not exceed 36 inches wide and 48 inches high.
6. Individual wall-mounted double-door enclosures shall not exceed 60 inches wide and 36 inches high.
7. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
8. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch-high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
2. Construct enclosure of steel, not less than:

- a. Enclosure size less than 24 in. (600 mm): 0.053 in. (1.35 mm) or 0.067 in. (1.7 mm) thick.
 - b. Enclosure size 24 in. (600 mm) and larger: 0.067 in. (1.7 mm) or 0.093 in. (2.36 mm) thick.
3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be selected by Architect.
 - b. Interior color shall be manufacturer's standard.
 4. Hinged door full size of front face of enclosure and supported using:
 - a. Enclosures sizes less than 36 in. (900 mm) tall: Multiple butt hinges.
 - b. Enclosures sizes 36 in. (900 mm) tall and larger: Continuous piano hinges.
 5. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size less than 24 in. (600 mm): Solid or perforated] steel, 0.053 in. (1.35 mm) thick.
 - b. Size 24 in. (600 mm) and larger: Solid aluminum, 0.10 in. (3 mm) or steel, 0.093 in. (2.36 mm) thick.
 6. Internal panel mounting hardware, grounding hardware and sealing washers.
 7. Grounding stud on enclosure body.
 8. Thermoplastic pocket on inside of door for record Drawings and Product Data.
- E. Wall Mounted NEMA 250, Types 4 and 12:
1. Enclosure shall be NRTL listed according to UL 508A.
 2. Seam and joints are continuously welded and ground smooth.
 3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
 4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
 5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide (1500 mm tall by 900 mm wide).
 6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide (900 mm tall by 1500 mm wide).
 7. Construct enclosure of steel, not less than the following:
 - c. Enclosure size less than 24 in. (600 mm): 0.053 in. (1.35 mm) or 0.067 in. (1.7 mm) thick.
 - a. Size 24 Inches (600 mm) and Larger: 0.067 inch (1.7 mm) thick.
 8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be as selected by Architect.
 - b. Interior color shall be manufacturer's standard.

9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
 - a. Sizes through 24 Inches (600 mm) Tall: Two hinges.
 - b. Sizes between 24 Inches (600 mm) through 48 Inches (1200 mm) Tall: Three hinges.
 - c. Sizes Larger 48 Inches (1200 mm) Tall: Four hinges.
10. Double-door enclosures with overlapping door design to include unobstructed full-width access.
 - a. Single-door enclosures 48 inches (1200 mm) and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - d. Size less than 24 in. (600 mm): Solid or perforated] steel, 0.053 in. (1.35 mm) thick.
 - a. Size 24 in. (600 mm) and larger: Solid aluminum, 0.10 in. (3 mm) or steel, 0.093 in. (2.36 mm) thick.
12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
13. Grounding stud on enclosure body.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

2.20 RELAYS

A. General-Purpose Relays:

1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Relays shall have LED indication and a manual reset and push-to-test button.
7. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 15 ms or less.
 - d. Dropout Time: 10 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2 VA.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.

9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a dust-tight cover.
6. Include knob and dial scale for setting delay time.
7. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
 - d. Repeatability: Within 2 percent.
 - e. Recycle Time: 45 ms.
 - f. Minimum Pulse Width Control: 50 ms.
 - g. Power Consumption: 5 VA or less at 120-V ac.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 15 ms or less.
 - d. Dropout Time: 10 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2 VA.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).
7. Equip relays with coil transient suppression to limit transients to non-damaging levels.

8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:

1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:

1. Description:
 - a. On-off control and status indication in a single device.
 - b. LED status indication of activated relay and current trigger.
 - c. Closed-Open-Auto override switch located on the load side of the relay.
2. Performance:
 - a. Ambient Temperature: Minus 30 to 140 deg F (Minus 34 to 60 deg C).
 - b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.
3. Status Indication:
 - a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
 - b. Current Sensor Range: As required by application.
 - c. Current Set Point: Fixed or adjustable as required by application.
 - d. Current Sensor Output:
 - 1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
 - 2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
 - 3) Analog, zero- to 5- or 10-V dc.
 - 4) Analog, 4 to 20 mA, loop powered.
4. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
5. Enclosure: NEMA 250, Type 1 enclosure.

2.21 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least 40 VA.
3. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:

1. General Power-Line Conditioner Requirements:

- a. Design to ensure maximum reliability, serviceability and performance.
- b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

2. Standards: NRTL listed per UL 1012.

3. Performance:

- a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
- b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.
 - 1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
 - 2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
 - 3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.
- c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
- d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
- e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
- f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
- g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.

- h. Attenuate load-generated odd current harmonics 23 dB at the input.
 - i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
 - j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
 - k. Common-mode noise attenuation of 140 dB.
 - l. Transverse-mode noise attenuation of 120 dB.
 - m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
 - n. Reliability of 200,000 hours' MTBF.
 - o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
 - p. Approximately 92 percent efficient at full load.
4. Transformer Construction:
- a. Ferro resonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
 - b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
 - c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
 - d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
 - e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
 - f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
 - g. Include interface terminals for output power hot, neutral and ground conductors.
 - h. Label leads, wires and terminals to correspond with circuit wiring diagram.
 - i. Vacuum impregnate transformer with epoxy resin.
5. Cabinet Construction:
- a. Design for panel or floor mounting.
 - b. NEMA 250, Type 1, general-purpose, indoor enclosure.
 - c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
 - d. Include a textured baked-on paint finish.
- C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:
- 1. The maximum continuous operating voltage shall be at least 125 percent.
 - 2. The operating frequency range shall be 47 to 63 Hz.
 - 3. Protection modes according to NEMA LS-1.
 - 4. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:
 - a. Line to Neutral: 45,000 A.
 - b. Neutral to Ground: 45,000 A.
 - c. Line to Ground: 45,000 A.
 - d. Per Phase: 90,000 A.

5. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:
 - a. Line to Neutral: 360 V.
 - b. Line to Ground: 360 V.
 - c. Neutral to Ground: 360 V.
6. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.
 - a. Line to Neutral:
 - 1) 100 kHz: 42 dB.
 - 2) 1 MHz: 25 dB.
 - 3) 10 MHz: 21 dB.
 - 4) 100 MHz: 36 dB.
 - b. Line to Ground:
 - 1) 100 kHz: 16 dB.
 - 2) 1 MHz: 55 dB.
 - 3) 10 MHz: 81 dB.
 - 4) 100 MHz: 80 dB.
7. Unit shall have LED status indicator that extinguishes to indicate a failure.
8. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
9. Unit shall not generate any appreciable magnetic field.
10. Unit shall not generate an audible noise.

D. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:
 - a. Output voltage nominally 25-V dc within 5 percent.
 - b. Output current up to 100 mA.
 - c. Input voltage nominally 120-V ac, 60 Hz.
 - d. Load regulation within 0.5 percent from zero- to 100-mA load.
 - e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.22 CONTROL WIRE AND CABLE

- A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 18 AWG.
 2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
 3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
 4. Conductor colors shall be black (hot), white (neutral), and green (ground).
 5. Furnish wire on spools.
- B. Single Twisted Shielded Instrumentation Cable above 24 V:
1. Wire size shall be a minimum No. 18 AWG.
 2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
 3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
 4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
 6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
 7. Furnish wire on spools.
- C. Single Twisted Shielded Instrumentation Cable 24 V and Less:
1. Wire size shall be a minimum No. 18 AWG.
 2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
 3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
 4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
 6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
 7. Furnish wire on spools.
- D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
1. Cable shall be plenum rated.
 2. Cable shall comply with NFPA 70.
 3. Cable shall have a unique color that is different from other cables used on Project.
 4. Copper Cable for Ethernet Network:
 - a. 1000BASE-T or 1000BASE-TX.
 - b. TIA/EIA 586, Category 5e or Category 6.
 - c. Minimum No. 24 AWG solid.
 - d. Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP).
 - e. Thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, Class CMP as plenum rated.

2.23 RACEWAYS FOR CONTROL WIRING, CABLEING AND TUBING

A. Metal Conduits, Tubing, and Fittings:

1. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with NEMA ANSI C80.1 and UL 6.
3. ARC: Comply with NEMA ANSI C80.5 and UL 6A.
4. IMC: Comply with NEMA ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit or IMC.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch (1 mm), minimum.
6. EMT: Comply with NEMA ANSI C80.3 and UL 797.
7. FMC: Comply with UL 1; zinc-coated steel or aluminum.
8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
9. Fittings for Metal Conduit: Comply with NEMA ANSI FB 1 and UL 514B.
 - a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 - b. Fittings for EMT:
 - 1) Material: Steel or die cast.
 - 2) Type: Setscrew or compression.
 - c. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 - d. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
10. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.24 OPTICAL FIBER CABLE AND CONNECTORS

A. Cables:

1. Performance Requirements:
 - a. Fiber: Multimode graded index. Core/cladding size shall be either 62.5/125 or 100/140 micrometers.
 - b. Numerical Aperture:
 - 1) 62.5/125 Micrometer Fiber: 0.275 plus or minus 0.015.
 - 2) 100/140 Micrometer Fiber: 0.29 plus or minus 0.015.

- c. Maximum Attenuation:
 - 1) 850 nm: 6.0 dB/km.
 - 2) 1300 nm: 5.0 dB/km.
 - d. Minimum Bandwidth Dispersion: 300 MHz-km at 850 nm.
 - e. Core/Cladding Index Difference: 0.3 percent plus or minus 0.05 percent, measured using refractive rear field measurement procedure.
 - f. Color-code finished fibers for easy identification.
 - g. Splice Loss: Fibers shall be spliced together to form a longer fiber using a commercially available fiber splicing machine recommended by cable manufacturer. Maximum loss per fiber splice shall be 0.20 dB.
 - h. Connection: Fibers shall be connected using fiber-optic connectors. Nominal connector loss shall not be greater than 1 dB.
 - i. Fiber-optic cable shall be suitable for use with 100Base-FX or 100Base-SX standard (as applicable) as defined in IEEE 802.3.
2. Mechanical and Environmental Requirements:
- a. Tensile Strength: Fiber cable shall withstand a minimum tensile strength of 2700 N with maximum elongation of less than 0.5 percent.
 - b. Bending Radius: Minimum static bending radius for cable shall be 10 times outside diameter for non-armored cables and 20 times outside diameter for armored cables. Non-armored cables shall withstand being flexed at minimum static bending radius plus or minus 90 degrees for at least 20 cycles at 20 to 40 cycles per minute at 20 deg C. Armored cables shall withstand being flexed at minimum static bending radius plus or minus 90 degrees for at least 10 cycles at 20 to 40 cycles per minute at 20 deg C.
 - c. Vibration: Cable shall withstand a vibration test with vibration amplitude of 5 mm and frequency of 10 cycles per second for at least five hours.
 - d. Twist: Cable shall withstand twisting of 360 degrees over a length of 2 m for at least 10 cycles at 10 cycles per minute.
 - e. Temperature: Cable shall withstand the following temperatures:
 - 1) Installation: Minus 30 to 70 deg C.
 - 2) Operation: Minus 40 to 70 deg C.
 - 3) Storage/Shipping: Minus 40 to 70 deg C.
 - f. Lifetime: Average lifetime of a 2-km, 12-fiber cable shall be at least 20 years when installed in a natural ambient environment. End of useful life shall be reached if failing to comply with requirements indicated or a spontaneous catastrophic fiber failure.
 - g. Crush Resistance: Cable shall withstand a compressive force of 705 N/cm for armored cables and 600 N/cm for non-armored cables. There shall be no attenuation increase after force is removed.
3. Cable Structure:

- a. Number of Fibers: Supply the required number of fibers in each cable for DDC system indicated, plus not less than 50 percent spare. Cable structure shall have fibers grouped for easy handling.
 - b. Strength Members: Include cable with strength members to satisfy mechanical and environmental conditions indicated.
 - c. Cable Core: Core shall consist of stranded buffer tubes around a central member of appropriate geometric size and shall be filled and bound to maintain core integrity. A fibrous strength member may be stranded around core to provide necessary strength for cable.
 - d. Cable Jacket: Protect cable by an extruded-polyethylene jacket.
 - e. Cable Armor: For cables requiring extra mechanical protection, one or two layers of galvanized corrugated steel tape coated by an anticorrosive compound shall be either helically or longitudinally applied over standard outer jacket. Apply a second outer jacket of polyethylene over coated steel tape. Thickness of sheaths and jackets are not specified as long as mechanical and environmental conditions are satisfied.
 - f. Cable Installation: Cables shall be suitable for a semiprotected outdoor installation.
4. Packaging and Shipping:
- a. Seal both ends of each length of cable.
 - b. Test individual fibers in each cable before shipping to verify compliance with Specifications.
- B. Connectors:
1. Performance Requirements:
 - a. Type: Fiber-optic connectors shall be either Type ST or Type SMA. Use either connector type exclusively. No substitutions are allowed.
 - b. Insertion Loss: Connector shall have an insertion loss of not greater than 1 dB.
 - c. Coupling Tolerance: Connector shall withstand at least 500 couplings with insertion loss within 0.25-dB tolerance limit.
 - d. Mechanical Requirements:
 - 1) Connector shall enclose outermost coating of single fiber cable and be able to be mated or unmated without using a tool.
 - 2) Mount connector rigidly in a metal frame.
 - 3) Connector shall allow a semiskilled person to properly install connector to a single fiber easily in a field environment with simple tools.
- C. Splice Organizer Cabinet:
1. Minimum Capacity: Each splice organizer shall accommodate number of connectors required for DDC system indicated, plus 100 percent spare.
 2. Mounting: Wall mount the splice organizer cabinet.
- D. Raceways:
1. Mechanical and Performance Requirements:

- a. Construction: Nonmetallic, flexible raceway system manufactured specifically for routing fiber-optic cables.
- b. Suitable for use in return-air plenums, air-handling rooms, above ceilings and under access floors.
- c. Exhibit low smoke generation and flame-spread characteristics, and have high-temperature service tolerance.
- d. Size raceway according to NFPA 70 requirements for communications cables.
- e. Tensile Strength at Yield: 10,800 psi.
- f. Elongation at Break: 25 percent.

E. Cable Identification:

1. Labeling product shall be self-laminating cable marker.
2. Cable labeling shall include numeric designation, source, destination, and cable type.

2.25 ACCESSORIES

A. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

B. Instrument Enclosures:

1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than 12 inches shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

2.26 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size shall be as follows:
 - a. Servers: Minimum of 0.5 inch (13 mm) high.
 - b. DDC Controllers: Minimum of 0.5 inch (13 mm) high.
 - c. Enclosures: Minimum of 0.5 inch (13 mm) high.
 - d. Electrical Power Devices: Minimum of 0.5 inch (13 mm) high.
 - e. UPS units: Minimum of 0.5 inch (13 mm) high.
 - f. Accessories: Minimum of 0.25 inch (6 mm) high.
 - g. Instruments: Minimum of 0.25 inch (6 mm) high.
 - h. Control Damper and Valve Actuators: Minimum of 0.25 inch (6 mm) high.
3. Tag shall consist of white lettering on black background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
5. Tag shall be fastened with drive pins.
6. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

C. Equipment Warning Labels:

1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch (6 mm) beyond white border.

2.27 SOURCE QUALITY CONTROL

- A. Testing Agency:** Engage a qualified testing agency to evaluate the following according to industry standards for each product, and to verify DDC system reliability specified in performance requirements:

1. DDC controllers.
2. Routers.

3. Operator workstations.
- B. Product(s) and material(s) will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for products to verify actual locations of connections before installation.
 1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
 2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

- A. Communication Interface to Equipment with Integral Controls:
 1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
 2. Equipment to Be Connected:
 - a. Roof-top units specified in Section 237413 "Packaged, Outdoor, Central-Station Air-Handling Units."
 - b. Switchboards specified in Section 262300 "Low-Voltage Switchgear."
 - c. Motor-control centers specified in Section 262419 "Motor-Control Centers."
 - d. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."
- B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:
 - a. Power monitoring specified in Section 260913 "Electrical Power Monitoring and Control."
 - b. Lighting controls specified in Section 260926 "Lighting Control Panelboards."
 - c. Lighting controls specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."
 - d. Lighting controls specified in Section 260943.23 "Relay-Based Lighting Controls."
 - e. Fire-alarm system specified in Section 283111 "Digital, Addressable Fire Alarm System."
 - f. Fire-alarm system specified in Section 283112 "Zoned (DC Loop) Fire-Alarm System."
 - g. Access controls specified in Section 281300 "Access Control."
 - h. Intrusion detection specified in Section 281600 "Intrusion Detection."

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
 1. DDC control dampers, which are specified in Section 230923.12 "DDC Control Dampers."
 2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
- C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
 1. DDC control valves, which are specified in Section 230923.11 "Control Valves."
 2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."
 3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 4. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 5. Pipe- and tank-mounted thermowells. Liquid thermowells are specified in Section 230923.27 "Temperature Instruments."

3.4 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

- A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer.
 - 1. Programmable application or application-specific controller.
 - 2. Unit-mounted DDC control dampers and actuators, which are specified in Section 230923.12 "Control Dampers."
 - 3. Unit-mounted airflow sensors, switches and transmitters, which are specified in Section 230923.14 "Flow Instruments."
 - 4. Unit-mounted pressure sensors, switches and transmitters, which are specified in Section 230923.23 "Pressure Instruments."
 - 5. Unit-mounted temperature sensors, switches and transmitters. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 - 6. Relays.

- B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.
 - 1. Programmable application or application-specific controller.
 - 2. Electric damper actuator. Dampers actuators are specified in Section 230923.12 "Control Dampers."
 - 3. Unit-mounted flow and pressure sensors, transmitters and transducers. Flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
 - 4. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 - 5. Relays.

3.5 GENERAL INSTALLATION REQUIREMENTS

- A. Install products to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.
- D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
- E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- F. Firestop penetrations made in fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

- G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."
- H. Welding Requirements:
 - 1. Restrict welding and burning to supports and bracing.
 - 2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
 - 3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
 - 4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.
- I. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.
- J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.6 POT INSTALLATION

- A. Install one portable operator terminal(s).
- B. Turn over POTs to Owner at Substantial Completion.
- C. Install software on each POT and verify that software functions properly.

3.7 SERVER INSTALLATION

- A. Install one server at location directed by Owner.
- B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed location in Shop Drawings.
- C. Install software indicated on server(s) and verify that software functions properly.
- D. Develop Project-specific graphics, trends, reports, logs, and historical database.
- E. Power servers through dedicated UPS unit. Locate UPS adjacent to server.

3.8 ROUTER INSTALLATION

- A. Install routers if required for DDC system communication interface requirements.
- B. Test router to verify that communication interface functions properly.

3.9 CONTROLLER INSTALLATION

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply.
- C. Install controller with latest version of applicable software and configure to execute requirements indicated.
- D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- E. Installation of Network Controllers:
 - 1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Top of controller shall be within 72 inches (1800 mm) of finished floor.
- F. Installation of Programmable Application Controllers:
 - 1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Top of controller shall be within 72 inches (1800 mm) of finished floor.
- G. Application-Specific Controllers:
 - 1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.10 INSTALLATION OF WIRELESS ROUTERS FOR OPERATOR INTERFACE

- A. Install wireless routers to achieve optimum performance and best possible coverage.
- B. Mount wireless routers in a protected location that is within 60 inches (1500 mm) of floor and easily accessible by operators.
- C. Connect wireless routers to field power supply and to UPS units if network controllers are powered through UPS units.

- D. Install wireless router with latest version of applicable software and configure wireless router with WPA2 security and password protection. Create access password with not less than 12 characters consisting of letters and numbers and at least one special character. Document password in operations and maintenance manuals for reference by operators.
- E. Test and adjust wireless routers for proper operation with portable workstation and other wireless devices intended for use by operators.

3.11 ENCLOSURES INSTALLATION

- A. Install the following items in enclosures, to comply with indicated requirements:
 - 1. Routers.
 - 2. Controllers.
 - 3. Electrical power devices.
 - 4. UPS units.
 - 5. Relays.
 - 6. Accessories.
 - 7. Instruments.
 - 8. Actuators
- B. Attach wall-mounted enclosures to wall using the following types of steel struts:
 - 1. For NEMA 250, Type 1 Enclosures: Use corrosion-resistant-coated steel strut and hardware.
 - 2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
 - 3. Install plastic caps on exposed cut edges of strut.
- C. Align top of adjacent enclosures.
- D. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.12 ELECTRIC POWER CONNECTIONS

- A. Connect electrical power to DDC system products requiring electrical power connections.
- B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.
- C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

- E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.13 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.
- B. Install engraved phenolic nameplate with unique identification on face for each of the following:
 - 1. Server.
 - 2. Router.
 - 3. Protocol analyzer.
 - 4. DDC controller.
 - 5. Enclosure.
 - 6. Electrical power device.
 - 7. UPS unit.
 - 8. Accessory.
- C. Install engraved phenolic nameplate with unique instrument identification on face of each instrument connected to a DDC controller.
- D. Install engraved phenolic nameplate with identification on face of each control damper and valve actuator connected to a DDC controller.
- E. Where product is installed above accessible tile ceiling, also install matching engraved phenolic nameplate with identification on face of ceiling grid located directly below.
- F. Where product is installed above an inaccessible ceiling, also install engraved phenolic nameplate with identification on face of access door directly below.
- G. Warning Labels:
 - 1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
 - 2. Shall be located in highly visible location near power service entry points.

3.14 NETWORK INSTALLATION

- A. Install fiber-optic cable when connecting between the following network devices and when located in different buildings on campus.
 - 1. Network controllers.
- B. Install copper or fiber-optic cable when connecting between the following network devices located in same building:
 - 1. Network controllers.

- C. Install copper cable when connecting between the following:
 - 1. Network controllers or programmable application controllers.
 - 2. Routers.
 - 3. Routers and network controllers or programmable application controllers.
 - 4. Network controllers and programmable application controllers.
 - 5. Programmable application controllers.
 - 6. Programmable application controllers and application-specific controllers.
 - 7. Application-specific controllers.

- D. Install network cable in continuous raceway.
 - 1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.15 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

- B. ASHRAE 135 Networks:
 - 1. MAC Address:
 - a. Every network device shall have an assigned and documented MAC address unique to its network.
 - b. Ethernet Networks: Document MAC address assigned at its creation.
 - c. ARCNET or MS/TP networks: Assign from 00 to 64.

 - 2. Network Numbering:
 - a. Assign unique numbers to each new network.
 - b. Provide ability for changing network number through device switches or operator interface.
 - c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

 - 3. Device Object Identifier Property Number:
 - a. Assign unique device object identifier property numbers or device instances for each device network.
 - b. Provide for future modification of device instance number by device switches or operator interface.
 - c. LAN shall support up to 4,194,302 unique devices.

 - 4. Device Object Name Property Text:
 - a. Device object name property field shall support 32 minimum printable characters.
 - b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

- 1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
 - 2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".
5. Object Name Property Text for Other Than Device Objects:
- a. Object name property field shall support 32 minimum printable characters.
 - b. Assign object name properties with plain-English names descriptive of application.
 - 1) Example 1: "Zone 1 Temperature."
 - 2) Example 2 "Fan Start and Stop."
6. Object Identifier Property Number for Other Than Device Objects:
- a. Assign object identifier property numbers according to [Drawings] [or] [tables] indicated.
 - b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.
- 3.16 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION
- A. Comply with NECA 1.
 - B. Comply with TIA 568-C.1.
 - C. Wiring Method: Install cables in raceways. Conceal raceway and cables except in unfinished spaces.
 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
 - D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - E. Field Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
 - F. Conduit Installation:
 1. Install conduit expansion joints where conduit runs exceed 200 feet (60 m), and conduit crosses building expansion joints.
 2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.

3. Maintain at least 3-inch (75-mm) separation where conduits run axially above or below ducts and pipes.
4. Limit above-grade conduit runs to 100 feet (30 m) without pull or junction box.
5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
6. Do not fasten conduits onto the bottom side of a metal deck roof.
7. Flexible conduit is permitted only where flexibility and vibration control is required.
8. Limit flexible conduit to 3 feet (1 m) long.
9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
10. Direct bury conduits underground or install in concrete-encased duct bank where indicated.
 - a. Use rigid, nonmetallic, Schedule 80 PVC.
 - b. Provide a burial depth according to NFPA 70, but not less than 24 inches (600 mm).
11. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
12. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
13. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
14. Offset conduits where entering surface-mounted equipment.
15. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:
 - a. Conduit extending from interior to exterior of building.
 - b. Conduit extending into pressurized duct and equipment.
 - c. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

G. Wire and Cable Installation:

1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
 - a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. UTP Cable Installation:
 - a. Comply with TIA 568-C.2.
 - b. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination, to maintain cable geometry.
6. Installation of Cable Routed Exposed under Raised Floors:
 - a. Install plenum-rated cable only.
 - b. Install cabling after the flooring system has been installed in raised floor areas.
 - c. Coil cable 6 feet (1.8 m) long not less than 12 inches (300 mm) in diameter below each feed point.
7. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.
8. Provide strain relief.
9. Terminate wiring in a junction box.
 - a. Clamp cable over jacket in junction box.
 - b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
10. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
11. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
12. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
13. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
14. Wire and cable shall be continuous from terminal to terminal without splices.
15. Use insulated spade lugs for wire and cable connection to screw terminals.
16. Use shielded cable to transmitters.
17. Use shielded cable to temperature sensors.
18. Perform continuity and meager testing on wire and cable after installation.
19. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation, and replace it with new cable.
20. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
21. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
22. Protection from Electro-Magnetic Interference (EMI): Provide installation free of (EMI). As a minimum, comply with the following requirements:

- a. Comply with BICSI TDMM and TIA 569-C for separating unshielded cable from potential EMI sources, including electrical power lines and equipment.
- b. Separation between open cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
- c. Separation between cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
- d. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
- e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches (1200 mm).
- f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.17 FIBER-OPTIC CABLE SYSTEM INSTALLATION

- A. Comply with TIA 568-C.3, except where requirements indicated are more stringent.
- B. Raceway Installation:
 - 1. Install continuous raceway for routing fiber-optic cables.
 - 2. Install raceways continuously between pull boxes and junction boxes. Raceways shall enter and be secured to enclosures.
 - 3. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

4. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Use long radius elbows for all fiber-optic cables.
5. Entire raceway shall be complete and raceway interior cleaned before installation of fiber-optic cables.
6. Securely fasten raceway to building structure using clamps and clips designed for purpose.
7. Install nylon or polyethylene pulling line in raceways. Clearly label as "pulling line," indicating source and destination.

C. Fiber-Optic Cable Installation:

1. Route cables as efficiently as possible, minimizing amount of cable required.
2. Continuously lubricate cables during pulling-in process.
3. Do not exceed maximum pulling tensions provided by cable manufacturer. Monitor cable pulling tension with a mechanical tension meter.
4. Arrange cables passing through pull boxes to obtain maximum clearance among cables within box.
5. As cables emerge from intermediate point pull boxes, coil cable in a figure eight pattern with loops not less than 24 inches (600 mm) in diameter.
6. Terminate fiber-optic cables in a fiber-optic splice organizer cabinet, unless connected equipment can accept fiber-optic cables directly. Terminate cables with connectors.
7. Install and connect appropriate opto-electronic equipment and fiber jumper cables between opto-electronic equipment and fiber-optic cable system to DDC system fiber-optic cable system. Verify interface compatibility.

D. Cable and Raceway Identification:

1. Label cables at both ends. Labels shall be typed, not handwritten.
2. Mark raceways at each pull box indicating the type and number of cables within.

3.18 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.

2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use a fiber-optic time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.19 DDC SYSTEM I/O CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
- D. Control Damper Checkout:
 1. Verify that control dampers are installed correctly for flow direction.
 2. Verify that proper blade alignment, either parallel or opposed, has been provided.
 3. Verify that damper frame attachment is properly secured and sealed.
 4. Verify that damper actuator and linkage attachment is secure.
 5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
 6. Verify that damper blade travel is unobstructed.
- E. Control Valve Checkout:
 1. Verify that control valves are installed correctly for flow direction.
 2. Verify that valve body attachment is properly secured and sealed.
 3. Verify that valve actuator and linkage attachment is secure.
 4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
 5. Verify that valve ball, disc or plug travel is unobstructed.
 6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.
- F. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
7. For temperature instruments:
 - a. Verify sensing element type and proper material.
 - b. Verify length and insertion.

3.20 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
- E. Provide diagnostic and test equipment for calibration and adjustment.
- F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
- G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
- H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
- I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- J. Analog Signals:
 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
3. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.21 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

- B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.
- C. Verify that spare I/O capacity is provided.

3.22 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
 - a. Upper quarter of range.
 - b. Lower quarter of range.
 - c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.23 DDC SYSTEM VALIDATION TESTS

- A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
- B. After approval of Test Plan, execute all tests and procedures indicated in plan.
- C. After testing is complete, submit completed test checklist.
- D. Pretest Checklist: Submit the following list with items checked off once verified:
 1. Detailed explanation for any items that are not completed or verified.
 2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.

3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
 - a. Verify analog I/O points at operating value.
 - b. Make adjustments to out-of-tolerance I/O points.
 - 1) Identify I/O points for future reference.
 - 2) Simulate abnormal conditions to demonstrate proper function of safety devices.

- 3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
 2. Simulate conditions to demonstrate proper sequence of control.
 3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
 4. After 24 Hours following Initial Validation Test:
 - a. Re-check I/O points that required corrections during initial test.
 - b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
 5. After 24 Hours of Second Validation Test:
 - a. Re-check I/O points that required corrections during second test.
 - b. Continue validation testing until I/O point is normal on two consecutive tests.
 6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
 7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.
- G. DDC System Response Time Test:
1. Simulate HLC.
 - a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and 50 percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.
 2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
 3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
 4. Purpose of test is to demonstrate DDC system, as follows:
 - a. Reaction to COV and alarm conditions during HLC.
 - b. Ability to update DDC system database during HLC.
 5. Passing test is contingent on the following:
 - a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of HLC.
 - b. All alarms, both binary and analog, are reported and printed; none are lost.
 - c. Compliance with response times specified.
 6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.24 DDC SYSTEM WIRELESS NETWORK VERIFICATION

- A. DDC system Installer shall design wireless DDC system networks to comply with performance requirements indicated.
- B. Installer shall verify wireless network performance through field testing and shall document results in a field test report.
- C. Testing and verification of all wireless devices shall include, but not be limited to, the following:
 1. Speed.
 2. Online status.
 3. Signal strength.

3.25 FINAL REVIEW

- A. Submit written request to Construction Manager when DDC system is ready for final review. Written request shall state the following:
 1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
 2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
 3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
 4. DDC system is complete and ready for final review.
- B. Review by Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

- E. Prepare and submit closeout submittals when no deficiencies are reported.
- F. A part of DDC system final review shall include a demonstration to parties participating in final review.
 - 1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
 - 2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
 - 3. Demonstration shall include, but not be limited to, the following:
 - a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
 - b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
 - c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
 - d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
 - e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
 - f. Trends, summaries, logs and reports set-up for Project.
 - g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
 - h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
 - i. Software's ability to edit control programs off-line.
 - j. Data entry to show Project-specific customizing capability including parameter changes.
 - k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 - l. Execution of digital and analog commands in graphic mode.
 - m. Spreadsheet and curve plot software and its integration with database.
 - n. Online user guide and help functions.
 - o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
 - p. System speed of response compared to requirements indicated.
 - q. For Each Network and Programmable Application Controller:
 - 1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.

- 2) Operator Interface: Ability to connect directly to each type of digital controller with a portable operator workstation and PDA. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
 - 3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
 - 4) Electric Power: Ability to disconnect any controller safely from its power source.
 - 5) Wiring Labels: Match control drawings.
 - 6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
 - 7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.
- r. For Operator Workstation:
- 1) I/O points lists agree with naming conventions.
 - 2) Graphics are complete.
 - 3) UPS unit, if applicable, operates.
- s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.
- 1) Data Presentation: On operator workstation, demonstrate graphic display capabilities.
 - 2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
 - 3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.
 - 4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
 - 5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
 - 6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
 - 7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
 - 8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
 - 9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.

10) Device and Network Management:

- a) Display of network device status.
- b) Display of BACnet Object Information.
- c) Silencing devices transmitting erroneous data.
- d) Time synchronization.
- e) Remote device re-initialization.
- f) Backup and restore network device programming and master database(s).
- g) Configuration management of routers.

3.26 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.27 MAINTENANCE SERVICE

- A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include monthly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.28 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two year(s).
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.29 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
- B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
- C. Training Schedule:
1. Schedule training with Owner 20 business days before expected Substantial Completion.
 2. Schedule training to provide Owner with at least 20 business days of notice in advance of training.
 3. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 15-minute break between sessions. Morning and afternoon sessions shall be separated by 60-minute lunch period. Training, including breaks and excluding lunch period, shall not exceed eight hours per day.
 4. Provide staggered training schedule as requested by Owner.
- D. Training Attendee List and Sign-in Sheet:
1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
 2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
 3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
 4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
 5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.
- E. Training Attendee Headcount:
1. Plan in advance of training for Owner supplied number of attendees.
 2. Make allowance for Owner to add up to two attendee(s) at time of training.
 3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.
- F. Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:
1. High school education and degree.
 2. Basic user knowledge of computers and office applications.
 3. Basic knowledge of HVAC systems.
 4. Basic knowledge of DDC systems.
 5. Basic knowledge of DDC system and products installed.

G. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

H. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

I. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
 - a. Daily operators.
 - b. Advanced operators.
 - c. System managers and administrators.
2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

J. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

K. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.

5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

L. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power and data connectivity for each attendee.
2. Provide capability to remotely access to Project DDC system for use in training.
3. Provide a workstation for use by each attendee.

M. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:

- a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
- b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
- c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
- d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
- e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
- f. Each control loop responds to set point adjustment and stabilizes within time period indicated.
- g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

N. Training Content for Advanced Operators:

1. Making and changing workstation graphics.
2. Creating, deleting and modifying alarms including annunciation and routing.
3. Creating, deleting and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting and modifying reports.
5. Creating, deleting and modifying points.
6. Creating, deleting and modifying programming including ability to edit control programs off-line.
7. Creating, deleting and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing and repairing hardware.
15. Adjusting, calibrating and replacing DDC system components.

O. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading and off-line archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.

6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification

P. Training requirements per the City of Philadelphia:

1. All training shall be coordinated with the Owner and with the Systems Integrator (if applicable)
2. Basic Operator Training:
 - a. One day (8 hours total) conduct training courses for designated personnel in the maintenance, service, and operation of the RBOp system and other systems as specified in the contract, including specified hardware and software. The training shall be oriented to those specific systems provided under this contract. The BAS Contractor is responsible for providing audiovisual equipment, manuals, instructors and other training material and supplies. The Systems Integrator shall review all training manuals, assist the BAS Contractors in conducting the training and coordinate training with the Owner.
3. Materials
 - a. Training manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Owner. Upon completion of this course, each student, using appropriate documentation, should be able to start the system, operate the system, recover the system after a failure, perform routine maintenance and describe the specific hardware architecture and operation of the system.
4. System Training and Coordination
 - a. If available, the BAS Contractor, Owner and Systems Integrator, shall provide 8 hours of training on the sequence of operations that includes Server level integration i.e. integration of lighting, card access, , etc. and other topics as requested by the Owner, or as listed in the FMCS section of the contractor.
5. Systems Follow-Up Training:
 - a. The BAS Contractor shall provide 12 hours of warranty follow up training, in no less than 4 hour increments, to be scheduled at the request of the owner during the one-year warranty period. These sessions address questions and advanced topics as requested by the owner.

Q. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 230923

R.

3.30 CONSTRUCTION WASTE MANAGEMENT (LEED)

- A. The contractor, subcontractors, and their personnel shall follow the procedures and practices for waste separation, collection, and transport as defined in the contractor's "Waste Management Plan" as required by Division 01 Section "Construction Waste Management."

END OF SECTION 230923

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SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.
 - 3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. [ABB \(Electrification Products Division\).](#)
 - 2. [Advanced Lightning Technology, Ltd.](#)
 - 3. [Appleton - O-Z/Gedney; Emerson Electric Co., Automation Solutions.](#)
 - 4. [Burndy; Hubbell Incorporated, Construction and Energy.](#)
 - 5. [Galvan Industries, Inc.; Electrical Products Division, LLC.](#)
 - 6. [ILSCO.](#)
 - 7. [nVent \(ERICO\).](#)
 - 8. [Siemens Industry, Inc., Energy Management Division.](#)

2.3 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. ~~Tinned Bonding Jumper: Tinned copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.~~
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- J. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- K. Straps: Solid copper, copper lugs. Rated for 600 A.

- L. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.
- M. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- N. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with stainless-steel bolts.
 - a. Material: Tin-plated aluminum.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; **3/4 inch by 10 feet (19 mm by 3 m)**.
- B. Ground Plates: **1/4 inch (6 mm)** thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 4/0 AWG minimum.
 - 1. Duct-Bank Grounding Conductor: Bury **12 inches (300 mm)** above duct bank when indicated as part of duct-bank installation.
- C. Grounding Conductors: Green-colored insulation, or Green-colored insulation with continuous yellow stripe.
- ~~D. Isolated Grounding Conductors: Green-colored insulation with more than one continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.~~
- ~~E.D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. ~~Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.~~
 - 2.1. ~~Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus. Install grounding buses in accordance with requirements as listed in the Motorola R56 standard.~~~~

~~F.E. Conductor Terminations and Connections:~~

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors ~~except at test wells and as otherwise indicated.~~
3. Connections to Ground Rods at Test Wells: Welded ~~Bolted~~ connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements and shall comply with Motorola R56, the more stringent shall apply.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so **4 inches (100 mm)** will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 4/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from **2 inches (50 mm)** above to **6 inches (150 mm)** below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4/0 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 24/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than **6 inches (150 mm)** from the foundation.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.

5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- ~~E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.~~
- F.E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- G.F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- H.G. Metallic Fences: Comply with requirements of IEEE C2 and shall comply with Motorola R56, the more stringent shall apply.
1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
 2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
 3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical

service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit. Equipotential bonding between grounding systems shall be performed at every third story.

- C. Ground Rods: Drive rods until tops are ~~302 inches (76250 mm)~~ below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. Use exothermic welds for all below-grade connections.
 - 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least ~~12 inches (300 mm)~~ deep, with cover.
 - 1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

- F. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use insulated copper ~~braided-type~~ bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

- G. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact. An approved antioxidant shall be applied on all mechanical connections.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces. An approved antioxidant shall coat all mechanical connections.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 263213.13 - DIESEL EMERGENCY ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes packaged diesel engine generators for emergency use with the following features:

- 1. Diesel engine.
- 2. Alternator.
- 3. Unit-mounted radiator.
- 4. Double Wall Sub-Base Diesel fuel-oil system.
- 5. Control and monitoring.
- 6. Generator overcurrent and fault protection.
- 7. Generator, exciter, and voltage regulator
- 8. Vibration isolation devices.
- 9. Level 3 Sound Attenuated Enclosure
- 10. Finishes.

- B. Related Requirements:

- 1. Section 263600 "Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.3 DEFINITIONS

- A. AREP: Auxiliary winding regulation excitation principle. Voltage support for the AVR comes from independent auxiliary windings located in the main stator.
- B. AVR: Automatic voltage regulator.
- C. EPS: Emergency power supply.
- D. EPSS: Emergency power supply system.
- E. Operational Bandwidth: The total variation, from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
- F. PMG: Permanent magnet generator. Voltage support for the AVR comes from an independent auxiliary permanent magnet generator which is mounted on the shaft extension of the alternator.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 2. Include thermal damage curve for generator.
 3. Include time-current characteristic curves for generator protective device.
 4. Include fuel consumption in **gallons per hour** at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
 5. Include airflow requirements for cooling and combustion air in **cubic feet per minute** at 0.8 power factor, and reference air-supply temperature. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
 6. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.
- B. Shop Drawings:
1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Identify fluid drain ports and clearance requirements for proper fluid drain.
 4. Design calculations for selecting vibration isolators and for designing vibration isolation bases.
 5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
 6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For engine generators to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
 - b. Operating instructions laminated and mounted adjacent to generator location.
 - c. Training plan.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years / 3000 Hour from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide MTU Onsite Energy Corporation Model MTU 12V1600 DS550 as supplied by the Emergency Systems Service Company at 215-536-4973 or a comparable product by one of the following:

1. [Cummins](#).
2. Caterpillar.

- B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. B11 Compliance: Comply with B11.19.

- B. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 EPSS.
- ~~4.5. Comply with NFPA 1221.~~

- C. UL Compliance: Comply with UL 2200.

- A. Engine Exhaust Emissions: Comply with EPA Tier 2 requirements and applicable state and local government requirements.

- B. Noise Emission: Comply with enclosure specification for maximum noise level due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and

discharge, and other components of installation. Comply with ISO 8528-10 for sound measurements at **23.0 feet (7 m)**.

- C. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: **Minus 20 to plus 50 deg C.**
 - 2. Relative Humidity: Zero to 100 percent.
 - 3. Altitude: Sea level to 1000 feet

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Service Load: 550 KW /687 kVA.
- D. Power Factor: 0.8 Lagging
- E. Frequency: 60 Hz
- F. Voltage: 277/480V ac.
- G. Phase: Three
- H. Induction Method: **Turbocharged.**
- I. Governor: Adjustable isochronous, with speed sensing.
- J. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
 - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.
- K. Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor.
 - 2. Nameplates: For each major system component to identify manufacturer's name, model, and serial number, of component.
- L. Engine Generator Performance:
80 degree temperature rise
 - 1. Steady-State Voltage Operational Bandwidth: 0.25 percent of rated output voltage, from no load to full load, and one-percent for non-PMG alternators.
 - 2. Load Factor: 85-percent load factor according to ISO 8528-1.

- a. If below, supplier shall provide updated documents for performance modified to 85% load factor in regards to time before overhaul (TBO) and the respective maintenance schedule.
3. Transient Voltage Performance: Not more than 15 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 3.5-seconds.
4. Steady-State Frequency Operational Bandwidth: 0.25 percent of rated frequency, from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
7. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically with PMG/AREP, without damage to generator system components.
9. Start Time: Comply with NFPA 110 system requirements.

2.4 DIESEL ENGINE

- A. Fuel: ASTM D 975 diesel fuel oil, Grade 2-D S15.
 1. Ultra-Low Sulfur Diesel
- B. Rated Engine Speed: 1800 rpm.
- C. Lubrication System: Engine or skid mounted.
 1. Filter and Strainer: Select according to engine manufacturer's requirements for particle removal.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- D. Jacket Coolant Heater: One (1) - 5000 watt, 208 volt single phase, electric-immersion type, factory installed and wired with isolation valves in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499
- E. Cooling System: 50 degree C ambient capacity of radiator. Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
 1. Coolant: Glycol-based antifreeze and water mixture for freeze protection to **0 deg F (minus 18 deg C)** with anticorrosion additives as recommended by engine manufacturer.

2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 100 percent load condition.
 3. Expansion Tank: Rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- F. Muffler/Silencer: Critical grade, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 18 dB.
- A. Air-Intake Filter: **Single-stage**, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- B. Starting System: 24 V electric, with negative ground.
1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: As required by NFPA 110.
 4. Battery: **Lead acid**, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide NFPA 110 specified cranking cycle without recharging.
 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Include accessories required to support and fasten batteries in place.
 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and minimum continuous rating.
 8. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for batteries. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

- d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
- e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
- f. Enclosure and Mounting: NEMA 250, Type 1 factory mounted and wired DC.

2.5 CONTROL AND MONITORING: MGC 3010 (Fully Enhanced)

- A. Automatic-Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- B. Manual-Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.
- D. Control and Monitoring Panel:
 - 1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
 - a. PLC logic incorporating drag and drop ladder logic available for the owner/user. Logic shall be designed such that all parameters within the generator set controller can be used in addition to additional inputs and outputs.
 - 2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
 - 3. Instruments: Located on the control and monitoring panel and viewable during operation.
 - a. Engine lubricating-oil pressure gage.
 - b. Engine-coolant temperature gage.
 - c. DC voltmeter (alternator battery charging).
 - d. Running-time meter.
 - e. AC voltmeter, **for each phase**
 - f. AC ammeter, for each phase
 - g. AC frequency meter.
 - h. Digital generator-voltage-adjusting feature to allow plus or minus 5 percent adjustment.
 - 4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm and pre-alarm indication as required by NFPA 110 for Level 1 system, including the following:

- a. Cranking control equipment.
- b. Run-Off-Auto switch.
- c. Control switch not in automatic position alarm.
- d. Overcrank alarm.
- e. Overcrank shutdown device.
- f. Low water temperature alarm.
- g. High engine temperature pre-alarm.
- h. High engine temperature.
- i. High engine temperature shutdown device.

- j. High engine exhaust temperature alarm.
- k. Overspeed alarm.
- l. Overspeed shutdown device.
- m. Low-fuel main tank.
 - 1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.
- n. Coolant low-level alarm.
- o. Coolant low-level shutdown device.
- p. Coolant high-temperature prealarm.
- q. Coolant high-temperature alarm.
- r. Coolant low-temperature alarm.
- s. Coolant high-temperature shutdown device.
- t. EPS load indicator.
- u. Battery high-voltage alarm.
- v. Low-cranking voltage alarm.
- w. Battery-charger malfunction alarm.
- x. Battery low-voltage alarm.
- y. Lamp test.
- z. Contacts for local and remote common alarm.

E – Communications

- 1 – ModBus RTU (RS-485)
- 2 – ModBus TCP-IP
- 3 – RDP-110
- 4 – CANBus
- 5 – Modem Interface (RS-232)
- 6- Ethernet

Provide 4 – Relay Board

Provide Ground Fault

- E. Remote Display Panel: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
 - 1. Overcrank alarm.
 - 2. Coolant low-temperature alarm.

3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Run-Off-Auto switch.
13. Control switch not in automatic position alarm.
14. Fuel tank derangement alarm.
15. Fuel tank high-level shutdown of fuel-supply alarm.
16. Lamp test.
17. Low-cranking voltage alarm.
18. Generator overcurrent protective device not closed.

- F. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

Pillar 3R Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

- G. Generator Circuit Breaker:

One (1) – Generator Output: 800 Amp. 100% rated, Electronic, LSI

2.6 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Marathon Model 573RSL4033 with PMG
- B. Comply with NEMA MG 1.
- C. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- D. Electrical Insulation: Class H or Class F.
- E. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- G. Enclosure: Dripproof
- H. Instrument Transformers: Mounted within generator enclosure.

- I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

LEVEL 3 SOUND ATTENUATED OUTDOOR ENGINE GENERATOR ENCLOSURE

- J. Description: Vandal-resistant, level 3 sound-attenuating, weatherproof steel housing. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Instruments and control shall be mounted within enclosure.
- K. Description: Skin Tight.
- L. Hinged Doors: Manufacturer's standard construction
- M. Muffler Location: Within enclosure.
- N. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 100 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
 - 1. Louvers: Fixed-engine, cooling-air inlet and discharge.

Sound Attenuation: When measured at **23.0 feet (7 m)** from sides of unit, attenuation shall be 81.2 dBA or less Open Field in accordance with ISO 8528-10 and ANSI S1. 13-2005. Octave band sound report shall be provided based on similar unit construction.

2.7 DIESEL FUEL-OIL SYSTEM

- A. Comply with NFPA 30.
- B. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.
- C. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:
 - 1. Tank level indicator.
 - 2. Fuel-Tank Capacity:72 Hour Full Load
 - 3. Leak detection in interstitial space.
 - 4. Vandal-resistant fill cap.

2.8 VIBRATION ISOLATION DEVICES

- A. Standard pad style vibration isolators

2.9 FINISHES

- A. Outdoor Enclosures and Components: **Powder-coated finish over steel** enclosure.

1. Components: Liquid paint.

2.10 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
 1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
 1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
 3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 4. Mounting: Adjacent to or integrated with control and monitoring panel.

2.11 SOURCE QUALITY CONTROL

- A. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 2. Test generator, exciter, and voltage regulator as a unit.
 3. Full-load run.
 4. Maximum power.
 5. Voltage regulation.
 6. Transient and steady-state governing.
 7. Single-step load pickup.
 8. Safety shutdown.
 9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
- B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than five working days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

3.3 INSTALLATION

- A. Comply with NECA 1 and NECA 404.
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.
- C. Equipment Mounting:
 - 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements.
 - 2. Coordinate size and location of concrete bases for packaged engine generator. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
 - 3. Install **engine generator in sound attenuated enclosure with pad style isolators** on minimum **4-inch- (100-mm-)** high concrete base. Secure to anchor bolts installed in concrete bases.
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

- D. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

~~A. Manufacturer's Field Service: Engage a third party NRTL qualified testing agency to perform tests and inspections.~~

~~A. Engage a factory authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.~~

B. Perform tests and inspections.

C. Tests and Inspections:

- 1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified. Certify compliance with test parameters.
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with Drawings and the Specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify that the unit is clean.
 - 5) Test protective relay devices.
 - 6) Verify phase rotation, phasing, and synchronized operation as required by the application.
 - 7) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
 - 8) Conduct performance test according to NFPA 110.
 - 9) Verify correct functioning of the governor and regulator.
- 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
- 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 7. Noise-Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, and compare measured levels with required values.
- D. Coordinate tests with tests for transfer switches, and run them concurrently.
- E. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- F. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- I. Remove and replace malfunctioning units and **retest** as specified above.
- J. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.
- K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component, indicating satisfactory completion of tests.

3.7 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include **12** months' full maintenance by skilled employees of manufacturer's authorized service representative. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

Addendum No. 1

THE CITY OF PHILADELPHIA
Office of Emergency Management

END OF SECTION 263213.13

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:
 - a. Surge suppression.
 - b. Rectifier-charger.
 - c. Inverter.
 - d. Controls and indications.
 - e. Static bypass transfer switch.
 - f. Internal maintenance bypass/isolation switch.
 - g. Output distribution section.
 - h. Battery and battery disconnect device.
 - i. Battery monitoring.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GTO: Gate turn-off thyristor.
- C. IGBT: Isolated gate bipolar transistor.
- D. LCD: Liquid-crystal display.
- E. LED: Light-emitting diode.
- F. NiCd: Nickel cadmium.
- G. PC: Personal computer.
- H. SPD: Surge protection device.
- I. THD: Total harmonic distortion.
- J. UPS: Uninterruptible power supply.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of UPS.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for UPS.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For UPS.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: One for every 10 of each type and rating, but no fewer than one set of each.
 - 2. Cabinet Ventilation Filters: One complete set(s).

1.7 WARRANTY

- A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, but not less than the following, based on annual average battery temperature of 77 deg F (25 deg C):
- B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.
 - 1. Special Warranty Period: one years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Double Conversion, IGBT:

- a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output. High-efficiency carrier stored trench IGBT, in both rectifier-charger and inverter circuits, provides a minimum of 97 percent efficiency for the UPS system at full load and a minimum of 94 percent efficiency at 50 percent load.
 - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to provide constant, regulated inverter power output to the load.
 - c. Power Failure: If normal power fails, the rectifier-charger and inverter use energy from the battery to supply constant, regulated power output to the load without switching or disturbance.
2. When power is restored at the normal supply terminals of the system, controls shall automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger shall supply power to the load through the inverter and simultaneously recharge the battery.
 3. If the battery becomes discharged and normal supply is available, the rectifier-charger shall charge the battery. The rectifier-charger shall automatically shift to float-charge mode on reaching full charge.
 4. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch shall switch the load to the normal ac supply circuit without disturbance or interruption.
 5. The output power converters shall produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter shall sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
 6. The inverter shall be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
 7. Should overloads persist past the time limitations, the automatic static transfer switch shall switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch shall return the load to the UPS system.
 8. If the battery is disconnected, the UPS shall supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

- C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:
 - 1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
 - 2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
 - 3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

- D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance:
 - 1. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).
 - 2. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
 - 3. Relative Humidity: Zero to 95 percent, noncondensing.
 - 4. Altitude: Sea level to 3300 feet (1220 m).

2.2 PERFORMANCE REQUIREMENTS

- A. UL Compliance: Listed and labeled by an NRTL to comply with UL 1778.

- B. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:
 - 1. Inverter is switched to battery source.
 - 2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
 - 3. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
 - 4. Load is 30 percent unbalanced continuously.

- C. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is ~~five~~ fifteen minutes.

- D. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10 percent and minus 15 percent from nominal voltage.

- E. Overall UPS Efficiency: Equal to or greater than 94 percent at 100 percent load, 94 percent at 75 percent load, and 93 percent at 25 percent load.

- F. Maximum Acoustical Noise: 65dBA, "A" weighting, emanating from any UPS component under any condition of normal operation, 65dBA measured from nearest surface of component enclosure.
- G. Maximum Energizing Inrush Current: Eight times the full-load current.
- H. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.
- I. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.
- J. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.
- K. Limitation of harmonic distortion of input current to the UPS shall be as follows:
 - 1. Description: Rectifier-charger circuits shall limit THD to 3 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
- L. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.
- M. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:
 - 1. 50 Percent: Plus or minus 3 percent.
 - 2. 100 Percent: Plus or minus 5 percent.
 - 3. Loss of AC Input Power: Plus or minus 1 percent.
 - 4. Restoration of AC Input Power: Plus or minus 1 percent.
- N. Input Power Factor: A minimum of 0.90 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.
- O. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging shall not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:
 - 1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
 - 2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
 - 3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
 - 4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.
- P. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

2.3 UPS SYSTEMS

- A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.
- B. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. [APC by Schneider Electric.](#)
 - 2. [Eaton.](#)
 - 3. [Liebert; a brand of Vertiv.](#)
 - 4. [Toshiba International Corporation.](#)
- C. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
- D. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
- E. Configuration: Field-assembled, multicabinet modular style units.
- F. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
- G. Maintainability Features: Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.
- H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- I. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

2.4 SURGE SUPPRESSION

- A. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.
 - 1. Use factory-installed surge suppressors tested according to IEEE C62.41.1.

2.5 RECTIFIER-CHARGER

- A. Description: Voltage source converter, six-pulse IGBT rectifier.
- B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
- C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

- D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
 - 1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.
- E. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger shall be matched to the battery type supplied.
- F. Lithium Ion Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging shall be terminated when the rate of temperature rise reaches 1.8 deg F (1 deg C) per minute. If the battery reaches 140 deg F (60 deg C) prior to reaching this rate of temperature rise, charging shall terminate. Chargers that determine full charge by voltage measurement to sense a 10-mV drop per cell when reaching full charge are also acceptable.

2.6 INVERTER

- A. Description: Pulse-width modulated, IGBT with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.7 CONTROLS AND INDICATIONS

- A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure and remote annunciator installed in 24/7 manned area of OEM space.
- B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
- C. Indications: Plain-language messages on a digital LCD.
 - 1. Quantitative indications shall include the following:
 - a. Input voltage, each phase, line to line.
 - b. Input current, each phase, line to line.
 - c. Bypass input voltage, each phase, line to line.
 - d. Bypass input frequency.
 - e. System output voltage, each phase, line to line.
 - f. System output current, each phase.
 - g. System output frequency.
 - h. DC bus voltage.
 - i. Battery current and direction (charge/discharge).
 - j. Elapsed time discharging battery.
 - 2. Basic status condition indications shall include the following:

- a. Normal operation.
 - b. Load-on bypass.
 - c. Load-on battery.
 - d. Inverter off.
 - e. Alarm condition.
3. Alarm indications shall include the following:
- a. Bypass ac input overvoltage or undervoltage.
 - b. Bypass ac input over frequency or underfrequency.
 - c. Bypass ac input and inverter out of synchronization.
 - d. Bypass ac input wrong-phase rotation.
 - e. Bypass ac input single-phase condition.
 - f. Bypass ac input filter fuse blown.
 - g. Internal frequency standard in use.
 - h. Battery system alarm.
 - i. Control power failure.
 - j. Fan failure.
 - k. UPS overload.
 - l. Battery-charging control faulty.
 - m. Input overvoltage or undervoltage.
 - n. Input transformer overtemperature.
 - o. Input circuit breaker tripped.
 - p. Input wrong-phase rotation.
 - q. Input single-phase condition.
 - r. Approaching end of battery operation.
 - s. Battery undervoltage shutdown.
 - t. Maximum battery voltage.
 - u. Inverter fuse blown.
 - v. Inverter transformer overtemperature.
 - w. Inverter overtemperature.
 - x. Static bypass transfer switch overtemperature.
 - y. Inverter power supply fault.
 - z. Inverter transistors out of saturation.
 - aa. Identification of faulty inverter section/leg.
 - bb. Inverter output overvoltage or undervoltage.
 - cc. UPS overload shutdown.
 - dd. Inverter current sensor fault.
 - ee. Inverter output contactor open.
 - ff. Inverter current limit.
4. Controls shall include the following:
- a. Inverter on-off.
 - b. UPS start.
 - c. Battery test.
 - d. Alarm silence/reset.
 - e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts. Location to be coordinated with owner.

2.8 STATIC BYPASS TRANSFER SWITCH

- A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.
- B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.
- C. Input SPD: ~~80 kA~~ shall comply with Motorola R56 standard.

2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

- A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
 1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
 2. Switch shall electrically isolate other UPS components to permit safe servicing.
 3. Switch shall electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but shall allow primary power to the UPS for testing.
- B. Comply with NEMA PB 2 and UL 891.
- C. Switch Rating: Continuous duty at rated full-load UPS current.
- D. Mounting Provisions: Internal to system cabinet.

2.10 BATTERY

- A. Description: Lithium-Ion units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. C&D Technologies, Inc.
 2. Eaton.
 3. EnerSys.
 4. Exide Technologies.
 5. Panasonic Corporation of North America; Industrial Devices.

- 6. APC.
- ~~5-7.~~ Vertiv.

- C. Description: : Lithium-Ion units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
 - 1. Factory assembled in an isolated compartment of UPS cabinet.
- D. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

2.11 BASIC BATTERY MONITORING

- A. Description: Continuous, real-time capture of battery performance data.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. APC by Schneider Electric.
 - 2. Eaton.
 - 3. Emerson Network Power Connectivity Solutions.
- C. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
- D. Battery compartment high-temperature detector initiates an alarm when smoke or a temperature greater than **167 deg F (75 deg C)** occurs within the compartment.
- E. Annunciation of Alarms: At UPS control panel and remotely.

2.12 ADDITIONAL BATTERY MONITORING

- A. Monitoring features and components shall include the following:
 - 1. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
 - 2. Connections for data transmission via RS-485 link, external signal wiring to electrical power monitoring and control equipment. External signal wiring and computer are not specified in this Section.
 - 3. USB ports for printer and accessories.
- B. Performance: Automatically measure and electronically record the following parameters on a routine schedule and during battery discharge events. During discharge events, record measurements timed to nearest second; including measurements of the following parameters:
 - 1. Total battery voltage and ambient temperature.

2.13 SOURCE QUALITY CONTROL

- A. Factory test complete UPS system before shipment. Use the same type of batteries that are part of final installation. Include the following:
 - 1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
 - 2. Full-load test.
 - 3. Transient-load response test.
 - 4. Overload test.
 - 5. Power failure test.
- B. Report test results. Include the following data:
 - 1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
 - 2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
 - 3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection according to Section 262813 "Fuses" if required for coordination with UPS overcurrent protective device requirements.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
 - 1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

- E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- F. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

3.3 GROUNDING

- A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems." Comply with Motorola R56 standard.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify each battery cell individually.

3.5 BATTERY EQUALIZATION

- A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.6 FIELD QUALITY CONTROL

- A. ~~Manufacturer's~~ Field Service: Engage a factory-authorized service representative or NRTL to test and inspect components, assemblies, and equipment installations, including connections.
- B. Tests and Inspections:
 - 1. Inspect interiors of enclosures, including the following:
 - a. Inspect anchorage, alignment, grounding, and required clearances.
 - b. Component type and labeling verification.
 - c. Ratings of installed components.
 - 2. Test electrical and mechanical interlock systems for correct operation and sequencing.
 - 3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a. Use of low-resistance ohmmeter according to Section 7.22.2.2 of NETA ATS.
 - b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or Table 100.12 of NETA ATS.
 - c. Perform thermographic survey according to Section 9 of NETA ATS.

4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.
 - a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 of NETA ATS.
 - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer's recommendation.
 - c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup, Use secondary current injection to test trip functions.
 - d. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data.
 - e. Verify operation of charging mechanism.
 - f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.
8. Test automatic transfer switches.
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, according to Section 7.22.3.1 of NETA ATS.
 - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
 - c. Perform a contact/pole-resistance test.
 - d. Verify settings and operation of control devices.
 - e. Calibrate and set all relays and timers according to Section 7.9 of NETA ATS.
 - f. Verify phase rotation, phasing, and synchronized operation as required by the application.
 - g. Perform automatic transfer tests.
 - 1) Simulate loss of normal power.
 - 2) Return to normal power.
 - 3) Simulate loss of emergency power.
 - 4) Simulate all forms of single-phase conditions.
 - h. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Time delay on transfer.
 - 3) Alternative source voltage-sensing and frequency-sensing relays.
 - 4) Automatic transfer operation.
 - 5) Interlocks and limit switch function.

- 6) Time delay and retransfer on normal power restoration.
9. Test direct current system's batteries.
 - a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
 - b.
 - c. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - d. Verify all charger functions and alarms.
 - e. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
 - f. Perform a load test according to manufacturer's published data or IEEE 450.
 - g. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - h. Test values.
 - 1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Charger float and equalize voltage levels shall be according to battery manufacturer's published data.
 - 3) The results of charger functions and alarms shall be according to manufacturer's published data.
 - 4) Cell voltages shall be within 0.05 V of each other or according to manufacturer's published data.
 - 5) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 6) Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
 - 7) Results of load tests shall be according to manufacturer's published data or IEEE 450.
 10. Test communication of status and alarms to remote monitoring equipment.
 11. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous 6 months according to NIST standards.
 - a. Simulate malfunctions to verify protective device operation.
 - b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
 - c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
 - d. Test output voltage under specified transient-load conditions.
 - e. Test efficiency at 50, 75, and 100 percent of rated loads.
 - f. Test remote status and alarm panel functions.
 - g. Test battery-monitoring system functions.
- C. The UPS system will be considered defective if it does not pass tests and inspections.

Addendum No. 1

- D. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.
- E. Prepare test and inspection reports.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

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SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes:
 - 1. Type 2 surge protective devices.
 - 2. Enclosures.
 - 3. Conductors and cables.
- B. Related Requirements:
 - 1. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: air of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. NRTL: Nationally recognized testing laboratory.
- F. OCPD: Overcurrent protective device.
- G. SCCR: Short-circuit current rating.
- H. SPD: Surge protective device.
- I. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.
- J. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.
- K. Type 3 SPDs: Point of utilization SPDs.

- L. Type 4 SPDs: Component SPDs, including discrete components, as well as assemblies.
- M. Type 5 SPDs: Discrete component surge suppressors, such as MOVs that may be mounted on a printed wiring board, connected by its leads or provided within an enclosure with mounting means and wiring terminations.
- N. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include electrical characteristics, specialties, and accessories for SPDs.
 - 2. NRTL certification of compliance with UL 1449.
 - a. Tested values for VPRs.
 - b. Inominal ratings.
 - c. MCOV, type designations.
 - d. OCPD requirements.
 - e. Manufacturer's model number.
 - f. System voltage.
 - g. Modes of protection.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

- A. **Manufacturers:** Subject to compliance with requirements included in this section, the Motorola R56 standard, and on contract drawing E-502, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- ~~1. ABB, Electrification Products Division.~~
- ~~2.1. ASCO Power Technologies.~~
- ~~3.2. Transtector.~~
- ~~4.3. Vertiv.~~
- ~~5. Eaton.~~
- ~~6. Schneider Electric USA, Inc.~~
- ~~7. Siemens Industry, Inc., Energy Management Division.~~

- B. Source Limitations: Obtain devices from single source from single manufacturer.
- C. Standards:
 - 1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.
 - 2. Comply with UL 1283.
- D. Product Options:
 - 1. Include LED indicator lights for power and protection status.
 - 2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3. Include two sets NEMA ICS 5, dry Form C contacts rated at 5 A and 250 V ac for remote monitoring of protection status.
 - 4. Include surge counter. May be an extra bolt-on device.
- E. Performance Criteria:
 - 1. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
 - 2. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 160 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
 - 3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:
 - a. Line to Neutral: 1000 V for 480Y/277 V & 600 V for 208Y/120 V.
 - b. Line to Line: 1800 V for 480Y/277 V & 1000 V for 208Y/120 V.
 - 4. SCCR: Equal or exceed 200 kA.
 - 5. Inominal Rating: 20 kA.

2.2 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

2.3 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's written instructions.
- C. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's written instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
 - 2. Do not exceed manufacturer's recommended lead length.
 - 3. Do not bond neutral and ground.
- D. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. SPDs that do not pass tests and inspections will be considered defective.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks in accordance with manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

Addendum No. 1

THE CITY OF PHILADELPHIA
Office of Emergency Management

END OF SECTION 264313

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. **The more stringent shall apply.**
- B. Systems, design, equipment, components, cabling, materials, installation, labeling, and testing shall comply with these reference documents, including the following:
1. ANSI/TIA-568.0-D, "Generic Telecommunications Cabling for Customer Premises", December 2015.
 2. ANSI/TIA-568.1-D, "Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements," September 2015.
 3. ANSI/TIA-568.2- ANSI/TIA-568.1-D, "Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements," September, 2015.D, "Balanced Twisted Pair Telecommunications Cabling and Components Standard", June 2018.
 4. ANSI/TIA-568.3-D, "Optical Fiber Cabling and Components Standard", October 2016.
 5. ANSI/TIA 569.~~ED~~, "~~Commercial Building Standards for Telecommunications Pathways & Spaces~~", **May 2019** ~~April 2015~~.
 6. ANSI/TIA 606-C, "Labeling and Administration Standards for Telecommunications Cabling in Commercial Buildings", June 2017.
 7. ANSI/TIA 607-~~DC~~, "**Telecommunication Bonding and Grounding (Earthing) for Customer Premises**" ~~Bonding and Grounding for Telecommunications Cabling and Equipment in Commercial Buildings~~, **July 2019** ~~November 2015~~.
 8. Motorola R56, "Standards and Guidelines for Communications Sites", latest edition
 9. National Electric Code, ANSI/NFPA 70-2014.
 10. BICSI "Telecommunications Distribution Methods Manual", 14th Edition, 2014.
 11. All other applicable electrical and building codes.

1.2 SUMMARY

- A. Section Includes:
1. Grounding conductors.
 2. Grounding connectors.
 3. Grounding busbars.
 4. Grounding labeling.
- B. Related Requirements:
1. Division 01 Section "Construction Waste Management"
 2. Division 01 Section "LEED Requirements" for additional LEED requirements.

1.3 DEFINITIONS

- A. BCT: Bonding conductor for telecommunications.
- B. TGB: Telecommunications grounding busbar.
- C. TMGB: Telecommunications main grounding busbar.
- D. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.
- E. **RBB: Rack bonding bar**
- F. **SBB: Sub-system bonding bar**
- G. **SRG: Signal reference grid**
- H. **SS: Stainless steel**

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 - 1. Ground rods.
 - 2. Ground and roof rings.
 - 3. BCT, TMGB, TGBs, and routing of their bonding conductors.
- B. Qualification Data: For installation supervisor, and field inspector.
- C. Qualification Data: For testing agency and testing agency's field supervisor.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - a. Result of the ground-resistance test measured at the point of BCT connection.
 - b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have **Motorola R56 certified** personnel ~~certified by BICSI~~ on staff.
 - 1. Installation Supervision: Installation shall be under the direct supervision of **Motorola R56 certified** ~~HFS Level 2~~ Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 2. Field Inspector: Currently **Motorola R56 certified personnel** ~~registered by BICSI as a designer RCDD~~ to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Comply with ANSI/TIA-607-C and Motorola R56 Manual.

2.2 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following **but not limited to:**
 - 1. Harger Lightning & Grounding.
 - 2. Panduit Corp.
 - 3. TE Connectivity Ltd.
- B. Comply with UL 486A-486B.
- C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 - 2. Cable Tray Equipment Grounding Wire: No. 6 AWG, meeting conductor size requirements as specified in ANSI/TIA-607-C and Motorola R56.
- D. Cable Tray Grounding Jumper:
 - 1. Factory manufactured and assembled.
 - 2. Minimum No. 6 AWG, Green-insulated ground wire, no longer than 12 inches, with 2-hole compression lugs, each with 1/4" bolt holes spaces 5/8" apart.
 - 3. Attach with grounding connector provided by cable tray manufacturer.
- E. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.

4. Bonding Cable: 28 kmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
5. Bonding Conductor: No. 6 AWG, stranded conductor. Refer to ANSI/TIA-607-C for the correct conductor size, based upon distance.
6. ~~Bonding Jumper: Tinned copper tape, braided conductors terminated with two hole copper ferrules; 1 5/8 inches wide and 1/16 inch thick.~~

F. **Lug shall be 300-series SS or as approved by R56.**

2.3 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following **but not limited to:**

1. Chatsworth Products, Inc.
2. Panduit Corp.
3. TE Connectivity Ltd.

B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

D. Signal Reference Grid Connectors: ~~Combination of compression wire connectors, access floor grounding clamps, bronze U bolt grounding clamps, and copper split bolt connectors, designed for the purpose.~~ **Bonding to SRG shall be by exothermic weld. Split bolt connections are not acceptable.**

E. Busbar Connectors: **Lugs shall be attached via 300-series SS and approved antioxidant** ~~Cast silicon bronze~~, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.

F. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following **but not limited to:**

1. Chatsworth Products, Inc.
2. Harger Lightning & Grounding.
3. Panduit Corp.

- B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with ANSI/TIA-607-C and Motorola R56 for use as an TMGB.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. ~~SBB TGB~~: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with ANSI/TIA-607-C and Motorola R56 for use as SBB TGB.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- D. ~~Rack and Cabinet Grounding Busbars~~ RBB: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with ANSI/TIA-607-C and Motorola R56. Predrilling shall be with holes for use with lugs specified in this Section.
1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet. **Copper should be tin-plated copper. Do not daisy chain between racks. Size of bar is dependent on rack size, not optional.**
 2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 3. Rack-Mounted Vertical Busbar: 72 or 36 inches long, with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 IDENTIFICATION

- A. Comply with R56 ANSI/TIA-606-C and UL-969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3 - EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT (LEED)

- A. The contractor, subcontractors, and their personnel shall follow the procedures and practices for waste separation, collection and transport as defined in the contractor's "Waste Management Plan" as required by Division 01 Section "Construction Waste Management."

3.2 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of BCT connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with ANSI/TIA-607-C and Motorola R56. **The more stringent shall apply.**

3.4 APPLICATION

- A. Conductors: Install stranded conductors **per project drawings** ~~for No. 6 AWG and larger unless otherwise indicated.~~
 - 1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 1 AWG.
- B. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

5. **No mechanical connections on exothermic welding in test wells. No bolted connections on grounding welds, only exothermic welds. When the connection is accessible, an 8-sq. in. bolted bonding plate may be used.**

C. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches.

D. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees. **Bend radius shall not be smaller than 8-inch radius. No one bend may be less than 90 degrees. A 3/4" conduit has factory bend less than 8-inch radius and shall not be used.**
2. Install without splices.
3. Support at not more than 36-inch intervals.
4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
 - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.5 GROUNDING ELECTRODE SYSTEM

- A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 4/0 AWG, and as required by ANSI/TIA-607-C and Motorola R56 **or smaller than the project documents, the more stringent shall apply.**

3.6 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches above finished floor unless otherwise indicated.
- B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.7 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 - 1. Use crimping tool and the die specific to the connector.
 - 2. Pretwist the conductor.
 - 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the TMGB with insulated bonding conductor. **R56 approved antioxidant.**
- ~~E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.~~
- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB using individual minimum 6 **No. 2** AWG bonding conductors **dependent upon distance, see R56.**
- G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame using minimum 2 AWG bonding conductor.
- H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard using minimum 2 AWG bonding conductor. **Bond to SBB if located within an adjacent space.**
- I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables. **Comply with R56.**
- J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section. **Comply with R56, the more stringent shall apply.**
- K. Access Floors: Bond all metal parts of access floors to the TGB.

~~3.8 IDENTIFICATION~~

- ~~A. Labels shall be preprinted or computer printed type.
 - 1. Label TMGB(s) with "fs TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.~~

- ~~2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.~~
- ~~3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"~~

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
 - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.
- D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.
- E. Grounding system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 270526

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SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Systems, design, equipment, components, cabling, materials, installation, labeling, and testing shall comply with these specifications and associated referenced documents, including the following:
 - 1. ANSI/TIA-568.0-D, "Generic Telecommunications Cabling for Customer Premises", December 2015.
 - 2. ANSI/TIA-568.1-D, "Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements," September 2015.
 - 3. ANSI/TIA-568.2-D, "Balanced Twisted Pair Telecommunications Cabling and Components Standard", June 2018.
 - 4. ANSI/TIA-568.3-D, "Optical Fiber Cabling and Components Standard", October 2016.
 - 5. ANSI/TIA 569.ED, "~~Commercial Building Standards for Telecommunications Pathways & Spaces~~", **May 2019** ~~April 2015~~.
 - 6. ANSI/TIA 606-C, "Labeling and Administration Standards for Telecommunications Cabling in Commercial Buildings", June 2017.
 - 7. ANSI/TIA 607-~~DC~~, "**Telecommunication Bonding and Grounding (Earthing) for Customer Premises**" ~~Bonding and Grounding for Telecommunications Cabling and Equipment in Commercial Buildings~~", **July 2019** ~~November 2015~~.
 - 8. **Motorola R56, "Standards and Guidelines for Communications Sites", latest edition**
 - 9. National Electric Code, ANSI/NFPA 70-2014.
 - 10. BICSI "Telecommunications Distribution Methods Manual", 14th Edition, 2014.
 - 11. All other applicable electrical and building codes.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Boxes, enclosures, and cabinets.
- B. Related Requirements:
 - 1. Division 01 Section "Construction Waste Management"
 - 2. Division 01 Section "LEED Requirements" for additional LEED requirements.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid conduit.
- C. IMC: Intermediate metal conduit.
- D. EMT: Electrical Metallic Tubing.
- E. PVC: Polyvinyl Chloride.
- F. RNC: Rigid No-metallic conduit for use as sleeves.
- G. RTRC: Reinforced thermosetting resin conduit.

1.4 ACTION SUBMITTALS

- A. Product data for the following:
 - 1. Surface pathways
 - 2. Wireways and fittings.
 - 3. Boxes, enclosures, and cabinets.
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of pathway groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
 - 3. Underground ducts, piping, and structures in location of underground enclosures and handholes.
- B. Qualification Data: For professional engineer.

- C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Appleton - O-Z/Gedney; Emerson Electric Co., Automation Solutions.
 - 2. Southwire Company.
 - 3. Western Tube and Conduit Corporation.
- C. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
 - 2. Comply with TIA-569-D.
- D. GRC: Comply with ANSI C80.1 and UL 6.
- E. ARC: Comply with ANSI C80.5 and UL 6A.
- F. IMC: Comply with ANSI C80.6 and UL 1242.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: Compression.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions were installed, and including flexible external bonding jumper.
 - 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for plenum installation unless otherwise indicated.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carlon; a brand of Thomas & Betts Corporation.
 - 2. Dura-Line.
 - 3. IPEX USA LLC.
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-D.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Crouse-Hinds; Eaton, Electrical Sector.
 - 2. Quazite; Hubbell Incorporated, Power Systems.
 - 3. Wiremold; Legrand North America, LLC.
- C. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-D.
 - 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
 - 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 - 4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
 - 5. Gangable boxes are allowed.
- D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- E. Metal Floor Boxes:
 - 1. Material: Sheet metal.
 - 2. Type: Fully adjustable fire-rated where installed in an existing structural floor slab. Fire rating of enclosure should be consistent with the fire rating of the structural floor slab.
 - 3. Shape: Rectangular for raised floor and circular for poke-thru.
 - 4. Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
3. NEMA 250, Type 3R for damp and wet locations.

G. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.

PART 3 - EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT (LEED)

- A. The contractor, subcontractors, and their personnel shall follow the procedures and practices for waste separation, collection and transport as defined in the contractor's "Waste Management Plan" as required by Division 01 Section "Construction Waste Management."

3.2 PATHWAY APPLICATION

- A. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT or RNC.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC or IMC.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT or innerduct.
5. Damp or Wet Locations: GRC or IMC.
6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, communications-cable pathway as applicable for entire length throughout in EMT.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.

- B. Minimum Pathway Size: 1-inch trade size for copper and aluminum cables, and 1 inch for optical-fiber cables.

1. Pathway size shall be in accordance with the manufacturer's specifications, instructions, and recommendations to maintain minimum bend radius unless otherwise indicated.
2. Pathway quantities and sizes shall be sufficient to accommodate the quantities, sizes, and types of cables indicated on the drawings.
 - a. Fill calculations shall be performed to determine the quantities and sizes of pathways based upon the indicated cables for the initial installation.

- C. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
- D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- E. Install surface pathways only where indicated on Drawings.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.3 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
 2. NECA/BICSI 568.
 3. TIA-569-D.
 4. NECA 101
 5. NECA 102.
 6. NECA 105.
 7. NECA 111.
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- C. Keep pathways at least 12 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- D. Complete pathway installation before starting conductor installation.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.
- G. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Stub-ups to Above Recessed Ceilings:
1. Use EMT, IMC, or RMC for pathways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

- K. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- L. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- M. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.
- N. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- O. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- P. Surface Pathways are not permitted:
- Q. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
 - 2. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- R. Expansion-Joint Fittings:
 - 1. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 2. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- S. Hooks:
 - 1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 - 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 - 3. Hook spacing shall allow no more than 6 inches of slack. The lowest point of the cables shall be no less than 6 inches adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 - 4. Space hooks no more than 5 feet o.c.
 - 5. Provide a hook at each change in direction.

- T. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to bottom of box unless otherwise indicated.
 - U. Do not install raceway and boxes within existing concrete or masonry walls.
 - V. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
 - W. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
 - X. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
 - Y. Set metal floor boxes level and flush with finished floor surface.
 - Z. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- 3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS
- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."
- 3.5 FIRESTOPPING
- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."
- 3.6 PROTECTION
- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Systems, design, equipment, components, cabling, materials, installation, labeling, and testing shall comply with these specifications and associated referenced documents, including the following:
 - 1. ANSI/TIA-568.0-D, "Generic Telecommunications Cabling for Customer Premises", December 2015.
 - 2. ANSI/TIA-568.1-D, "Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements," September 2015.
 - 3. ANSI/TIA-568.2-D, "Balanced Twisted Pair Telecommunications Cabling and Components Standard", June 2018.
 - 4. ANSI/TIA-568.3-D, "Optical Fiber Cabling and Components Standard", October 2016.
 - 5. ANSI/TIA 569.~~ED~~, "~~Commercial Building Standards for~~ Telecommunications Pathways & Spaces", **May 2019** ~~April 2015~~.
 - 6. ANSI/TIA 606-C, "Labeling and Administration Standards for Telecommunications Cabling in Commercial Buildings", June 2017.
 - 7. ANSI/TIA 607-~~DC~~, "**Telecommunication Bonding and Grounding (Earthing) for Customer Premises**" ~~Bonding and Grounding for Telecommunications Cabling and Equipment in Commercial Buildings~~, **July 2019** ~~November 2015~~.
 - 8. Motorola R56, "Standards and Guidelines for Communications Sites", latest edition
 - 9. National Electric Code, ANSI/NFPA 70-2014.
 - 10. BICSI "Telecommunications Distribution Methods Manual", 14th Edition, 2014.
 - 11. All other applicable electrical and building codes.

1.2 SUMMARY

- A. Section Includes:
 - 1. Wire-mesh cable tray.
 - 2. Cable Supports.
 - 3. Warning signs.
- B. Related Requirements:
 - 1. Division 01 Section "Construction Waste Management"
 - 2. Division 01 Section "LEED Requirements" for additional LEED requirements
 - 3. Section 260536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of cable tray.
 - 1. Include data indicating dimensions and finishes for each type of cable tray indicated.
 - 2. Include data for supports and connecting hardware.

- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
 - 2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to sides of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
 - 2. Vertical and horizontal offsets and transitions.
 - 3. Clearances for access above and to side of cable trays.
 - 4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- ~~A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.~~

- B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
 - 2. Component Importance Factor: 1.5.

- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS AND J-HOOKS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
- B. Obtain cable trays and all required hardware and associated components from a single manufacturer.
- C. Sizes and Configurations: See the Drawings for specific requirements for types, materials, sizes, and configurations.
- D. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:
 1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 WIRE-MESH CABLE TRAY

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. B-line; Eaton, Electrical Sector.
 2. Cablofil; Legrand North America, LLC.
 3. MP Husky USA Cable Tray & Cable Bus.
- B. Description:
 1. Provide wire basket cable tray of types and sizes indicated with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the additional construction highlighted in Section 2.2
 2. All straight section longitudinal wires shall be constructed with a continuous top wire safety edge. Safety edge must be kinked and T-welded on all tray sizes.
 3. Wire basket cable tray shall be made of high strength steel wires and formed into a standard 2 inch by 4-inch wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.
- C. Wire basket cable tray sizes shall conform to the following nominal criteria:
 1. Straight sections shall be furnished in standard 118.3-inch lengths.
 2. Wire diameter shall be 0.196" (5mm) minimum on all mesh sections (minimum size of 4.5mm on stainless steel).
 3. Wire basket cable tray shall have a 2 inch or 4-inch usable loading depth with widths shown on the drawings provided.

- D. Material and Finishes: Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A510, Grade 1008 and shall be hot dipped galvanized after fabrication in accordance with ASTM A123.
- E. All fittings shall be field formed from straight sections in accordance with manufacturer's instructions.
- F. Dividers to separate copper and fiber optic cabling and patch cords shall be provided as shown on the drawings.
- G. Wire basket cable tray supports shall be center support hangers, trapeze hangers or wall brackets as provided by cable tray manufacturer.
- H. Trapeze hangers or center support hangers shall be supported by 1/4" inch or 3/8" inch diameter rods.
- I. Special accessories shall be furnished as required to protect, support and install a wire basket cable tray system.

2.4 CABLE SUPPORTS/J-HOOKS

- A. Cable supports that will be utilized to transport cabling shall meet or exceed the following requirements:
 - 1. Designed to support Category-5e/6/6A cabling while maintaining the minimum required bend radius for the cabling installed.
 - 2. Available in sizes from 1" through 4" diameters.
 - 3. Designed to be placed in an air-handling plenum environment.
 - 4. Furnished with required support hardware to allow for independent attachment to overhead support structure.
- B. Manufacturers:
 - 1. Erico/Caddy.
 - 2. Cooper B-Line.
 - 3. Panduit

2.5 WARNING SIGNS

- A. Lettering: 1-1/2-inch high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

2.6 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT (LEED)

- A. The contractor, subcontractors, and their personnel shall follow the procedures and practices for waste separation, collection and transport as defined in the contractor's "Waste Management Plan" as required by Division 01 Section "Construction Waste Management."

3.2 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA VE 2.
- B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.
- E. Join cable tray with splice plates; use four square neck-carriage bolts and locknuts.
- F. Fasten cable tray supports to building structure and install seismic restraints.
- G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb.
- H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- J. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.
- K. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- L. Make changes in direction and elevation using manufacturer's recommended fittings.
- M. Make cable tray connections using manufacturer's recommended fittings.
- N. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."

- O. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- P. Install cable trays with enough workspace to permit access for installing cables.
- Q. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.3 CABLE TRAY SUPPORTS

- A. Support cable tray assemblies in accordance with the following:
 - 1. Provide supports on both sides of a splice connecting two straight horizontal sections within the distance between the splice and the adjacent straight section quarter point (at a distance not more than 24" from the splice point).
 - 2. Provide a support at each straight horizontal section within 24" of its entry into a tee or cross or elbow fitting.
 - 3. Provide a support at the mid-point of each elbow except for 12" radius and 30 degree and 45 degree elbows.
 - 4. Provide a support for each side rail of each tee and cross.
 - 5. Provide intermediate supports where necessary to eliminate unsupported horizontal spans in excess of 10'-0".
 - 6. Provide supports for vertical runs on centers not in excess of 8'-0".
 - 7. Supports and their fastenings to building structure shall be sized to support safely the weight of the cable tray assemblies plus one pound for each twelve cubic inches of volume they contain based on their nominal dimensions.
 - 8. Each support shall be equipped with a hold down device to eliminate a relative motion between it and the cable tray section it carries.
- B. The inside of cable tray systems shall present no sharp edges, burrs or projections which could damage cable insulation.
- C. Expansion connectors shall be provided in accordance with NEMA standards and the manufacturer's recommendations.
- D. At support points, threaded rod must be hung from concrete inserts, clamps or devices that are securely fastened into the slab, wall or beam sufficiently to carry the load of the tray and its contents with a safety factor of 3.
- E. Cable tray systems shall not be used as walkways unless specifically designed and installed for that purpose.
- F. Cable tray shall be installed with complete access from either side to allow cable to be laid directly into the tray in lieu of pulling.

3.4 CABLE TRAY GROUNDING

- A. Ground cable trays **per Motorola R-56** ~~according to NFPA 70 unless additional grounding is specified.~~ Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."
- B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer. Provide anti-oxidizing compound at each bonding connection.
- E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.5 J-HOOK INSTALLATION

- A. Furnish and install the specified J-Hook assemblies in the sizes shown on the drawings provided.
- B. Each J-Hook shall be supported independently from the structure. Do not attached J-Hooks to the supports of other structures (light fixtures, electrical conduits, HVAC ducts, etc.).

3.6 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. Fasten cables on vertical runs to cable trays every 18 inches.
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

3.7 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

- B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorqued in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

- B. Prepare test and inspection reports.

3.9 PROTECTION

- A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Systems, design, equipment, components, cabling, materials, installation, labeling, and testing shall comply with these reference documents, including the following:
 - 1. ANSI/TIA-568.0-D, "Generic Telecommunications Cabling for Customer Premises", December 2015.
 - 2. ANSI/TIA-568.1-D, "Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements," September 2015.
 - 3. ANSI/TIA-568.2-D, "Balanced Twisted Pair Telecommunications Cabling and Components Standard", June 2018.
 - 4. ANSI/TIA-568.3-D, "Optical Fiber Cabling and Components Standard", October 2016.
 - 5. ANSI/TIA 569.~~ED~~, "~~Commercial Building Standards for Telecommunications Pathways & Spaces~~", **May 2019** April 2015.
 - 6. ANSI/TIA 606-C, "Labeling and Administration Standards for Telecommunications Cabling in Commercial Buildings", June 2017.
 - 7. ANSI/TIA 607-~~DC~~, "**Telecommunication Bonding and Grounding (Earthing) for Customer Premises**" ~~Bonding and Grounding for Telecommunications Cabling and Equipment in Commercial Buildings~~", **July 2019** November 2015.
 - 8. Motorola R56, "Standards and Guidelines for Communications Sites", latest edition
 - 9. National Electric Code, ANSI/NFPA 70-2014.
 - 10. BICSI "Telecommunications Distribution Methods Manual", 14th Edition, 2014.
 - 11. All other applicable electrical and building codes.

1.2 SUMMARY

- A. Section Includes:
 - 1. Category 6 twisted pair cable.
 - 2. Category 6a twisted pair cable.
 - 3. Twisted pair cable hardware, including plugs and jacks.
 - 4. Cable management system.
 - 5. Cabling identification products.
 - 6. Grounding provisions for twisted pair cable.
 - 7. Source quality control requirements for twisted pair cable.
- B. Related Requirements:
 - 1. Division 01 Section "Construction Waste Management"
 - 2. Division 01 Section "LEED Requirements" for additional LEED requirements.

1.3 DEFINITIONS

- A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. EMI: Electromagnetic interference.
- C. FTP: Shielded twisted pair.
- D. F/FTP: Overall foil screened cable with foil screened twisted pair.
- E. F/UTP: Overall foil screened cable with unscreened twisted pair.
- F. IDC: Insulation displacement connector.
- G. LAN: Local area network.
- H. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- J. RCDD: Registered Communications Distribution Designer.
- K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- L. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- M. S/FTP: Overall braid screened cable with foil screened twisted pair.
- N. S/UTP: Overall braid screened cable with unscreened twisted pairs.
- O. UTP: Unscreened (unshielded) twisted pair.

1.4 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
 - 1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
 - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately 100 sq. ft., and includes the components that extend from the equipment outlets to the station equipment.

- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

1.5 ACTION SUBMITTALS

- A. Manufacturer Certification: The contractor shall be manufacturer-certified to install the specified cabling system that will provide a manufacturer's extended warranty of 20-years (minimum). The contractor shall submit proof of the manufacturer's certification as part of the bid response.
- B. Product Data: For each type of product.
- C. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 3. Cabling administration Drawings and printouts.
 - 4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.
 - c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Telecommunications conductor drop locations.
 - f. Typical telecommunications details.
 - g. Mechanical, electrical, and plumbing systems.
- D. Twisted pair cable testing plan.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, installation supervisor, and field inspector.
- B. Product Certificates: For each type of product.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Test Records and Reports, in both printed and electronic formats.
- B. As-built drawings.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Connecting Blocks: One of each type.
 - 2. Faceplates: One of each type.
 - 3. Jacks: Ten of each type.
 - 4. Patch-Panel Units: One of each type.
 - 5. Plugs: Ten of each type.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings, and field testing program development by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test each pair of twisted pair cable for open and short circuits.
- B. Factory test UTP cable in reels in accordance with ANSI/TIA 568.2.D
- C. Cable will be considered defective is it does not pass tests and inspections.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.2~~1~~, when tested according to test procedures of this standard. **Use level IV tester for UTP up to 600MHz. Cable testing with appropriate (Level IV - TDR tester) must report 'Pass' of all links, a '* Pass' is not acceptable. Repair or replace any link that does not report 'Pass'.**
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.
- D. The solution offered by the bidder shall be a complete systems solution. The bidder shall be certified by the manufacturer (or manufacturers) to provide the Owner with a manufacturer's extended warranty of 20 years (minimum).
 - 1. All Category-6 cabling shall be supplied by the same manufacturer.
 - 2. All Category-6 connectivity, such as jack inserts, patch panels, and patch cords, shall be supplied by the same manufacturer.
 - 3. All Category-6a cabling shall be supplied by the same manufacturer.
 - 4. All Category-6a connectivity, such as jack inserts, patch panels, and patch cords, shall be supplied by the same manufacturer.

2.2 CATEGORY 6 TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belden CDT Networking Division/NORDX.
 - 2. Berk-Tek Leviton; a Nexans/Leviton alliance.
 - 3. SYSTIMAX Solutions; a CommScope Inc. brand.
- C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP)
- F. Cable Rating: Plenum.
- G. Jacket:
 - 1. Gray thermoplastic: Voice cabling.
 - 2. Blue thermoplastic: Data cabling.

2.3 CATEGORY 6a TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6a cable at frequencies up to 500MHz.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belden CDT Networking Division/NORDX.
 - 2. Berk-Tek Leviton; a Nexans/Leviton alliance.
 - 3. SYSTIMAX Solutions; a CommScope Inc. brand.
- C. Standard: Comply with TIA-568-C.2 for Category 6a cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP).
- F. Cable Rating: Plenum.
- G. Jacket: Blue thermoplastic.

2.4 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belden CDT Networking Division/NORDX.
 - 2. Berk-Tek Leviton; a Nexans/Leviton alliance.
 - 3. SYSTIMAX Solutions; a CommScope Inc. brand.
- C. General Requirements for Twisted Pair Cable Hardware:
 - 1. Comply with the performance requirements of Category 6, Category 6a.
 - 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 - 3. Cables shall be terminated with connecting hardware of same category or higher.
- D. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.
- E. Connecting Blocks:
 - 1. 110-style IDC for Category 6.
 - 2. 110-style IDC for Category 6a.
 - 3. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

- F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - 1. Number of Terminals per Field: One for each conductor in assigned cables.
- G. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
 - 1. Features:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 48 ports, "Black" in color.
 - 2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
 - 3. Number of Jacks per Field: One for each four-pair cable indicated.
- H. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with an eight-position modular plug at each end.
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall have color-coded boots for circuit identification.
- I. Plugs and Plug Assemblies:
 - 1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Standard: Comply with TIA-568-C.2.
 - 3. Marked to indicate transmission performance.
- J. Jacks and Jack Assemblies:
 - 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Designed to snap-in to a patch panel or faceplate.
 - 3. Standard: Comply with TIA-568-C.2.
 - 4. Marked to indicate transmission performance.
 - A. Jack inserts shall be supplied in the following colors:
 - 1. "Gray" in color: Voice cabling.
 - 2. "Blue" in color: Data cabling.
- K. Faceplate:
 - 1. Faceplate for Fixed Wall Installation:
 - a. High-impact plastic, 1-, 2-, and 4-port configurations. Coordinate color with owner.
 - b. For use with snap-in jacks accommodating any combination of UTP and coaxial work area cords.

- c. Identification: Machine printed, using adhesive-tape label.
- 2. Faceplate for Systems Furniture Installation:
 - a. High-impact plastic, maximum of 4-port configurations. Coordinate color with owner.
 - b. Designed to fit and function with the specified and installed systems furniture.
 - c. For use with snap-in jacks accommodating any combination of UTP and coaxial work area cords.
 - d. Furnish and install bank inserts for all unused port.
 - e. Identification: Machine printed, using adhesive-tape label.
- 3. Surface-Mounted Box:
 - a. High-impact plastic, 1- and 2-port configurations. Coordinate color with owner.
 - b. For use with snap-in jacks accommodating any combination of UTP and coaxial work area cords.
 - c. Identification: Machine printed, using adhesive-tape label.
- 4. Module Frames:
 - a. High-impact plastic, 1-, 2-, and 4-port configurations. Coordinate color with owner.
 - b. Available for installation in either 106 Duplex or Decora faceplates or spaces.
 - c. For use with snap-in jacks accommodating any combination of UTP and coaxial work area cords.
 - d. Identification: Machine printed, in the field, using adhesive-tape label.
- 5. Coordinate colors with Owner and architect before purchase.
- L. Approved Manufacturers:
 - 3. Ortronics.
 - 4. Commscope Uniprise.
 - 5. Leviton.
 - 6. Hubbell.
 - 7. Or approved equal
- M. Legend:
 - 1. Machine printed, in the field, using adhesive-tape label.
 - 2. Snap-in, clear-label covers and machine-printed paper inserts.
 - 3. Direct download circuit labeling into labeling printer.

2.5 IDENTIFICATION PRODUCTS

- A. Comply with ANSI/TIA-606-C and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.6 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with ANSI/TIA-607-C and Motorola R56, "Standards and Guidelines for Communications Sites", latest edition

2.7 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test cables on reels according to TIA-568-C.1.
- C. Factory test twisted pair cables according to TIA-568-C.2.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 CONSTRUCTION WASTE MANAGEMENT (LEED)

- A. The contractor, subcontractors, and their personnel shall follow the procedures and practices for waste separation, collection and transport as defined in the contractor's "Waste Management Plan" as required by Division 01 Section "Construction Waste Management."

3.2 WIRING METHODS

- A. Wiring Method: Install cables in pathways within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal pathways and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.3 INSTALLATION OF PATHWAYS

- A. Comply with Section 270528 "Pathways for Communications Systems."
- B. Comply with Section 270536 "Cable Trays for Communications Systems."
- C. Drawings indicate general arrangement of pathways and fittings.

3.4 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
 - 2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
 - 5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 6. MUTOA shall not be used as a cross-connect point.
 - 7. Consolidation points may be used only for making a direct connection to equipment outlets:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for twisted-pair cables at least 49 feet from communications equipment room.
 - 8. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 9. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 10. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
 - 11. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
 - 12. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 13. In the communications equipment room, install a 10-foot- long service loop on each end of cable.

14. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
 15. **Do not lace or train cables as this will cause an increase in alien crosstalk; maximum bundle size to be 24 for capacity of raised floor and for PoE applications.**
- C. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 48 inches apart. Provide J-Hook cable supports that are dedicated to horizontal cabling.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- D. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
 2. Install cabling after the flooring system has been installed in raised floor areas.
 3. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.
- E. Group connecting hardware for cables into separate logical fields.
- F. Separation from EMI Sources:
1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
 4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.5 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.6 GROUNDING

- A. Comply with ANSI/TIA-607-C and Section 270526 "Grounding and Bonding for Communications", and Motorola R56, "Standards and Guidelines for Communications Sites", latest edition.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B.
 1. Administration Class: Class 2.
 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2 level of administration, including optional identification requirements of this standard.
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- E. Cable and Wire Identification:
 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.

3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
 - b. Label each unit and field within distribution racks and frames.
 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Visually inspect UTP jackets for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with ANSI/TIA- 568.1-D.
 2. Visually confirm Category 6 and 6a marking of outlets, faceplates, jack inserts, connectors, and patch panels.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 4. Provide test results for each cable in electronic and printed format.
 5. UTP Performance Tests:
 - a. Test each Category-6 and Category-6a cable between patch panel and individual outlet locations for compliance with ANSI/TIA-568.1-D and ANSI/TIA-568.2.D for a Category-6 and 6a permanent link.
 - b. Perform the following tests according to ANSI/TIA-568.1-D and ANSI/TIA-568.2.D:
 - 1) Wire map.
 - 2) Length (physical vs. electrical, and length requirements).
 - 3) Insertion loss.
 - 4) Near-end crosstalk (NEXT) loss.
 - 5) Power sum near-end crosstalk (PSNEXT) loss.
 - 6) Attenuation to crosstalk ratio far-end (ACR-F) loss.
 - 7) Power-sum attenuation to crosstalk ratio far-end (PSACR-F) loss.
 - 8) Return loss.
 - 9) Propagation delay.
 - 10) Delay skew.
- B. Document data for each measurement. Save and present all test results for each cable in graphical format.

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- C. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports. Testing results shall be provided in both printed and electronic format to the Owner for review and approval prior to final acceptance. The Owner reserves the right to reject any installation that does not comply with the requirements, and will require the Contractor to provide such documentation at no additional cost.
- F. Test reports shall indicate testing instrument(s) utilized, factory calibration dates, testing methods, tests performed, dates performed, and results. Save all test results in graphical and tabular format.

END OF SECTION 271513

SECTION 281353.11 - AUDIO / VIDEO (A/V) INTERCOM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Audio / Video (A/V) Intercom

1.2 RELATED SECTIONS

- A. Section 27 15 13 - Communications Copper Horizontal Cabling.
- B. Section 28 15 00 - Access Control Hardware Devices.

1.3 REFERENCES

- A. American National Standards Institute (ANSI/TIA/EIA) 568 - Commercial Building Telecommunications Cabling Standard.
- B. International Organization for Standards (ISO) 9001:2000 - Quality Management Systems - Requirements.

1.4 SYSTEM DESCRIPTION

- A. Audio / Video (A/V) Intercom System: A network-based communication and security access control system featuring audio and video entry security, internal communication, emergency stations, and paging.
- B. All Master Units and applications in the systems shall be able to unlock doors remotely via direct wired connection to the security access control system, or over a network connection, assist onsite visitors from an offsite location, broadcast emergency announcements, and communicate using a PoE network.
 - 1. Power Source: Power over Ethernet (802.3af).
 - 2. Network Interface: 10 BASE-T / 100 BASE-TX Ethernet (RJ-45).
 - 3. Network Protocols: IPv4, IPv6, TCP, UDP, SIP, HTTP, HTTPS, MJPEG, RTSP, RTP, RTCP, IGMP, MLD, SMTP, DHCP, NTP, DNS.
 - 4. Bandwidth Usage:
 - a. G.711: 64Kbps x 2 per video call.
 - b. 64Kbps per monitor.
 - c. H.264: 24Kbps ~ 2,048Kbps.
 - 5. Communication: Hands-free (VOX), push-to-talk (simplex), or handset (full-duplex).
 - 6. Video Display: 7-inch color LCD.
 - 7. Camera: Type:
 - a. 1/3-inch color CMOS. 1.23 Megapixels.
 - b. View Area at 0-degree camera angle mounted at 4 feet 11 inches (1500 mm)
AFF: 2-feet 3-inches (700 mm) vertical x 3-feet 9-inch (1150 mm) horizontal at 19-inches (500 mm).
 - 8. Video Stream: ONVIF Profile S.
 - 9. Door Release: Programmable Form C dry contact, 24V AC/ DC, 500mA (use RY-24L for larger contact rating, which requires 24V DC power supply) or use RY-IP44 with

- 4 multipurpose relays.
- 10. Wire Type: CAT-6.
- 11. Distance:
 - a. Any station to Network Node: 330 feet (100 meters).

1.5 SUBMITTALS

- A. Submit under provisions of requirements in Division 1.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Shop Drawings: Submit the following:
 - 1. Wiring Diagrams: Indicate wiring for each item of equipment and interconnections between items of equipment.
 - 2. Include manufacturer's names, model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.
- D. Installation and Operation Manuals:
 - 1. Submit manufacturer's installation and operation manual, including operation instructions and component wiring diagrams.
 - 2. Provide detailed information required for Owner to properly operate equipment.
- E. Warranty: Submit manufacturer's standard warranty.
- F. Selection Samples: For each finish product specified, two complete sets of color chips representing manufacturer's full range of available colors and patterns.
- G. Verification Samples: For each finish product specified, two samples, minimum size 6 inches (150 mm) square, representing actual product, color, and patterns.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001:2015 certified company.
- B. Installer Qualifications: Factory trained and experienced with system installations of scope and size required for the Project.
- C. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.
- D. Storage: Store materials in clean, dry area indoors in accordance with manufacturer's instructions.
- E. Handling: Protect materials during handling and installation to prevent damage.

1.7 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturers include:
 - 1. Aiphone Corp., IP Video Intercom System: IX Series Intercom System
 - 2. Hubbell, Hubbcom IP Devices
 - 3. Axis, 2N IP System
- B. Requests for substitutions will be considered in accordance with provisions of Section 01 60 00 - Product Requirements.

2.2 SYSTEM DESIGN

- A. Master Station(s): Provide two (2) Master Stations.
 - 1. One will be located in the EOC, on the Supervisor platform
 - 2. One will be located in the RIC, on the center desk.
 - 3. Stations shall have color monitor
 - 4. Master Station Shall provide:
 - a. Audio and video communications with remote call stations
 - b. Remote camera control
 - c. Remote door release
- B. Audio / Video Call Stations:
 - 1. Surface Mounted: Provide one (1) located at the elevator lobby doors.
 - 2. A/V Call Stations shall provide:
 - a. Audio and video communications with remote master stations
 - b. Dual pushbutton operation, for direct selection of Master station (EOC or RIC).
 - c. Stainless Steel Enclosure
 - d. Color camera
 - e. Ability to provide A/V output to A/V system.
 - f. Ability to provide video images to recording or switching system
- C. Provide Contact input at door station.
 - 1. Stainless Steel Enclosure Model SBX-ISDVF:
 - a. 18-Guage Stainless Steel Surface Mount Box for IS-SS/IS-DVF/IS-IPDVF/IX-DF(SS)/IX-DF-HID/RP10 designed for surface mounting door stations.
 - b. Size: 10-7/16 inches x 5-15/16 inches x 3-5/16 inches (top); 2-5/16 inches (bottom) (265 mm x 151 mm x 84 mm (top); 59 mm (bottom).
 - c. Weather resistant.
 - d. Vandal-resistant.
 - e. Inside space for cabling.
 - f. Mounts to flat wall surface.
 - g. Opening at bottom for drainage.
 - 2. Stainless Steel Enclosure Model SBX-IDVFRA:
 - a. 18-Guage Stainless Steel Surface Mount Box for IS-DVF-(2)RA, IX-DF-2RA, IX-SS-(2)RA.
 - b. Size: 11-11/16 inches x 7 inches x 3-5/16 inches (top); 2-5/16 inches (bottom) (297 mm x 178 mm x 84 mm (top); 59 mm (bottom).
 - c. Weather resistant.
 - d. Vandal-resistant.
 - e. Inside space for cabling.

- f. Mounts to flat wall surface.
 - g. Opening at bottom for drainage.
- D. Wall Boxes:
- 1. Product: WB-CA Stainless Steel Wall Mount Box with Blue Assistance Signage and a Light Cage.
 - a. ADA (28 CFR Part 36 section 4.4.1) compliant.
 - b. Lettering: Reflective lettering on both sides of box.
 - c. Blue Beacon and Strobe: Mounted on top, enclosed in vandal resistant cage.
 - d. Material: 12-gauge stainless steel.
 - e. UL Listed electrical box included. 1-gang pattern internal mounting above UL box
 - f. Surface Mounting: 4 inch (102 mm) depth, ADA compliant.
 - g. Voltage: 24V DC.
 - h. Current: 200 mA.
 - i. Service: Vandal and weather resistant.
 - j. Compatibility: IX-DVF-2RA, IX-DVF-RA, IX-SSA-2RA, IX-SSA-RA, IS-DVF-2RA, IS-SS-2RA-R, and IS-SS-RA-R emergency and assistance substations.
 - 2. Product: WB-CE Stainless Steel Wall Mount Box with Red Emergency Signage and a Light Cage.
 - a. ADA (28 CFR Part 36 section 4.4.1) compliant.
 - b. Lettering: Reflective lettering on both sides of box.
 - c. Blue Beacon and Strobe: Mounted on top, enclosed in a vandal resistant cage.
 - d. Material: 12-gauge stainless steel.
 - e. UL Listed electrical box included. 1-gang pattern internal mounting above UL box
 - f. Surface Mounting: 4 inch (102 mm) depth, ADA compliant.
 - g. Voltage: 24V DC.
 - h. Current: 200 mA.
 - i. Service: Vandal and weather resistant.
 - j. Compatibility: IX-DVF-2RA, IX-DVF-RA

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive integrated security and communication system.

3.2 PREPARATION

- A. Verify the following compliance before starting installation.
 - 1. The unit turns inoperative during power failure.
 - 2. Keep the intercom wires at least 1 foot (30 cm) away from strong electrical wiring (AC 100-240 V) including, in particular, wiring for inverter electrical appliances. Noise and malfunction could result.
 - 3. If a strong light shines on the main unit screen, the picture may turn white or only silhouettes will be visible.
 - 4. Other manufacturer's devices (such as sensor, detectors, door releases) used with this system, comply with the manufacturer's installation requirements.
 - 5. The LCD panel is manufactured with very high precision techniques, inevitably will have a very small portion of its picture elements always lit or not lit at all. This is not

considered a unit malfunction. Please be aware of this in advance.

3.3 INSTALLATION

- A. Install integrated security and communication system in accordance with manufacturer's instructions at locations indicated on the Drawings.
- B. Mount equipment plumb, level, square, and secure. For video entrance stations and video door stations, comply with manufacturer's design requirements to provide optimum picture quality of station monitoring.

3.4 SET-UP AND ADJUSTING

- A. Adjust integrated security and communication system for proper operation in accordance with manufacturer's instructions.

3.5 DEMONSTRATION AND TRAINING

- A. Demonstration:
 - 1. Demonstrate that integrated security and communication system functions properly.
 - 2. Perform demonstration at final system inspection by qualified representative of manufacturer.
- B. Instruction and Training:
 - 1. Provide instruction and training of Owner's personnel as required for operation of integrated security and communication system.
 - 2. Provide hands-on demonstration of operation of system components and complete system, including user-level program changes and functions.
 - 3. Provide instruction and training by qualified representative of manufacturer.

3.6 PROTECTION

- A. Protect installed integrated security and communication system from damage during construction.

END OF SECTION

SECTION 282000 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes a video surveillance system consisting of cameras, digital video recorder, data transmission wiring, and a control station with its associated equipment.
- B. Related Requirements:
 - 1. Division 01 Section "Construction Waste Management"
 - 2. Division 01 Section "LEED Requirements" for additional LEED requirements.

1.3 DEFINITIONS

- A. AGC: Automatic gain control.
- B. BNC: Bayonet Neill-Concelman - type of connector.
- C. B/W: Black and white.
- D. CCD: Charge-coupled device.
- E. FTP: File transfer protocol.
- F. IP: Internet protocol.
- G. LAN: Local area network.
- H. MPEG: Moving picture experts group.
- I. NTSC: National Television System Committee.
- J. PC: Personal computer.
- K. PTZ: Pan-tilt-zoom.
- L. RAID: Redundant array of independent disks.
- M. TCP: Transmission control protocol - connects hosts on the Internet.

- N. UPS: Uninterruptible power supply.
- O. WAN: Wide area network.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
 - 3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
 - 4. UPS: Sizing calculations.
 - 5. Wiring Diagrams: For power, signal, and control wiring.
- C. Design Data: Include an equipment list consisting of every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NECA 1.
- C. Comply with NFPA 70.
- D. D.Electronic data exchange between the video surveillance system and access-control system shall comply with SIA TVAC.

1.7 PROJECT CONDITIONS

- A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Control Station: Rated for continuous operation in ambient temperatures of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
 2. Interior, Controlled Environment: System components, except central-station control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
 3. Interior, Uncontrolled Environment: System components installed in non-air-conditioned or temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250 enclosures.
 4. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. The video surveillance system for this project shall conform to the standards and requirements of the City of Philadelphia's video surveillance system architecture, and shall easily interface with existing CCTV systems and equipment.
- B. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.
1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- C. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened

or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NECA 1.
- C. Comply with NFPA 70.
- D. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

2.3 DIGITAL VIDEO MANAGEMENT SYSTEM

- A. The video surveillance system for this project shall use IP based network cameras and shall be capable of operating and being managed by the existing video network management system by Genetec being provided by the base building.

2.4 IP CAMERAS

- A. Indoor:
 - 1. Color Dome Camera: Assembled and tested as a manufactured unit, containing fixed color camera, varifocal lens, and vandal resistant dome assembly.
 - 2. Comply with UL 639.
 - 3. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination.
 - 4. Networked device, operating via IEEE 802.3 Power over Ethernet.
 - 5. Camera Electronics:
 - a. Scanning system: progressive.
 - b. Image Sensor: 1/4" or 1/3" CMOS.
 - c. Maximum of 3 Megapixel resolution
 - d. DC Auto-Iris lens control.
 - e. Resolution (minimum): 720p.
 - 6. Lens types:
 - a. Auto-iris
 - b. True day/night functionality.
 - c. Camera systems available with a variety of lens types and focal lengths.
 - 7. Manually selectable modes for backlight compensation or normal lighting.
 - 8. Available as "Standard" and 180-Degree systems
 - 9. Provide all wall and ceiling mounting hardware and brackets. Coordinate color of mounting hardware with owner and architect before installation.
 - 10. Manufacturers and Part Numbers:
 - a. Bosch Flexidome Series
 - b. Or approved equal

2.5 NETWORK VIDEO RECORDING EQUIPMENT

- A. Cameras added under this project will utilize existing network video recording equipment by Genetec being provided by the base building.

2.6 POWER SUPPLIES

- A. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera.
- B. Annunciation: Indicate change in system condition and switching of system or component to backup power.

PART 3 - EXECUTION

3.1 EXAMINATION

A. CONSTRUCTION WASTE MANAGEMENT (LEED)

- 1. The contractor, subcontractors, and their personnel shall follow the procedures and practices for waste separation, collection and transport as defined in the contractor's "Waste Management Plan" as required by Division 01 Section "Construction Waste Management."
- B. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
- C. Examine roughing-in for LAN, WAN, and IP network before device installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING

- A. Comply with requirements in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Install cables in raceways unless otherwise indicated.
 - 1. Except raceways are not required in accessible indoor ceiling spaces and attics.
 - 2. Except raceways are not required in hollow gypsum board partitions.
 - 3. Conceal raceways and wiring except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical

connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

- E. For communication wiring, comply with the following:
 - 1. ~~Section 271313 "Communications Copper Backbone Cabling."~~
 - 2. ~~Section 271323 "Communications Optical Fiber Backbone Cabling."~~
 - 3. ~~Section 271333 "Communications Coaxial Backbone Cabling."~~
 - 4. Section 271513 "Communications Copper Horizontal Cabling."
 - 5. ~~Section 271523 "Communications Optical Fiber Horizontal Cabling."~~
 - 6. ~~Section 271533 "Communications Coaxial Horizontal Cabling."~~
- F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Install cameras and infrared illuminators level and plumb.
- B. Install cameras with 84-inch- minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
- D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
- E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
- F. Avoid ground loops by making ground connections only at the control station.
 - 1. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.
- G. Identify system components, wiring, cabling, and terminals according to Section 270553 "Identification for Communications Systems."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
 - a. Prepare equipment list described in "Informational Submittals" Article.
 - b. Verify operation of auto-iris lenses.
 - c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
 - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
 - e. Set and name all preset positions; consult Owner's personnel.
 - f. Set sensitivity of motion detection.
 - g. Connect and verify responses to alarms.
 - h. Verify operation of control-station equipment.
3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

E. Video surveillance system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
 1. Check cable connections.
 2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
 3. Adjust all preset positions; consult Owner's personnel.

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4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
5. Provide a written report of adjustments and recommendations.

3.6 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 282000

SECTION 31 20 00 - EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Preparing subgrades for slabs-on-grade.
2. Drainage course for concrete slabs-on-grade.
3. Subbase course for concrete walks and pavements.
4. Excavating and backfilling trenches for utilities and pits for buried utility structures.

1.3 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

C. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

D. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

E. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

F. Fill: Soil materials used to raise existing grades.

- G. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- H. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- I. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct preexcavation conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

- A. Material test reports.

1.6 FIELD CONDITIONS

- A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth-moving operations.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D2487, or a combination of these groups.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.

- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
- H. Drainage Course: Narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.

2.2 ACCESSORIES

- A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored to comply with local practice or requirements of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.3 EXCAVATION FOR STRUCTURES AND SLABS-ON-GRADE

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 - 2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

3.4 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.5 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
 - 1. Clearance: 12 inches each side of pipe or conduit.
- C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
 - 1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.6 SUBGRADE INSPECTION

- A. Proof-roll subgrade below slabs on grade and pavements with a pneumatic-tired dump truck to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
- B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean

concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.8 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- D. Trenches under Roadways: Provide 4-inch-thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- E. Initial Backfill: Place and compact initial backfill of subbase material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- F. Final Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
- G. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:

1. Under walks and pavements, use satisfactory soil material.
2. Under steps and ramps, use engineered fill.
3. Under building slabs, use engineered fill.
4. Under footings and foundations, use engineered fill.

3.11 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.12 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D698:
 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 92 percent.
 3. For utility trenches, compact each layer of initial and final backfill soil material at 92 percent.

3.13 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:
 1. Walks: Plus or minus 1 inch.
 2. Pavements: Plus or minus 1/2 inch.

3.14 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:
 - 1. Shape subbase course and base course to required crown elevations and cross-slope grades.
 - 2. Place subbase course and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 - 3. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D698.

3.15 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 - 2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D698.

3.16 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform inspections:
- B. Testing Agency: Engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.17 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 20 00